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Muthiah et al.

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(45) **Date of Patent: Aug. 4, 2015**

(54) **SYSTEMS AND METHODS FOR MANAGING SPILLOVER LIMITS IN A MULTI-CORE SYSTEM**

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(51) **Int. Cl.**
G01R 31/08 (2006.01)
G06F 11/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G06F 9/5011*** (2013.01); ***H04L 47/19*** (2013.01); ***H04L 67/1002*** (2013.01); ***H04L 67/1025*** (2013.01); *G06F 2209/504* (2013.01); *G06F 2209/5011* (2013.01); *Y02B 60/142* (2013.01)

(58) **Field of Classification Search**
CPC H04L 47/19; G06F 9/2011
USPC 370/235, 392, 401
See application file for complete search history.

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Primary Examiner — Shirpal Khajuria
Assistant Examiner — Farhad Ali
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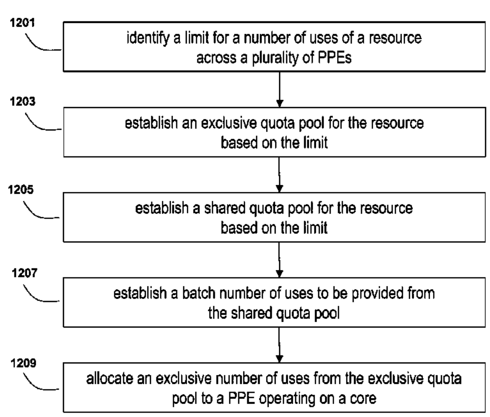
(57) **ABSTRACT**

The present disclosure is directed to a system for managing spillover via a plurality of cores of a multi-core device intermediary to a plurality of clients and one or more services. The system may include a device intermediary to a plurality of clients and one or more services. The system may include a spillover limit of a resource. The device may also include a plurality of packet engines operating on a corresponding core of a plurality of cores of the device. The system may include a pool manager allocating to each of the plurality of packet engines a number of resource uses from an exclusive quota pool and shared quota pool based on the spillover limit. The device may also include a virtual server of a packet engine of the plurality of packet engines. The virtual server manages client requests to one or more services. The device determines that the number of resources used by a packet engine of the plurality of packet engine has reached the allocated number of resource uses of the packet engine, and responsive to the determination, forwards to a backup virtual server a request of a client of the plurality of clients received by the device for the virtual server.

18 Claims, 29 Drawing Sheets



(51) **Int. Cl.**

G08C 15/00	(2006.01)
H04J 1/16	(2006.01)
H04J 3/14	(2006.01)
H04L 1/00	(2006.01)
H04L 12/26	(2006.01)
H04L 12/28	(2006.01)
H04L 12/56	(2006.01)
G06F 9/50	(2006.01)
H04L 12/801	(2013.01)
H04L 29/08	(2006.01)

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2003/0229697	A1	12/2003	Borella	
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2008/0077792	A1	3/2008	Mann	
2008/0123525	A1	5/2008	Miyoshi et al.	
2008/0181213	A1	7/2008	Ovsiannikov et al.	
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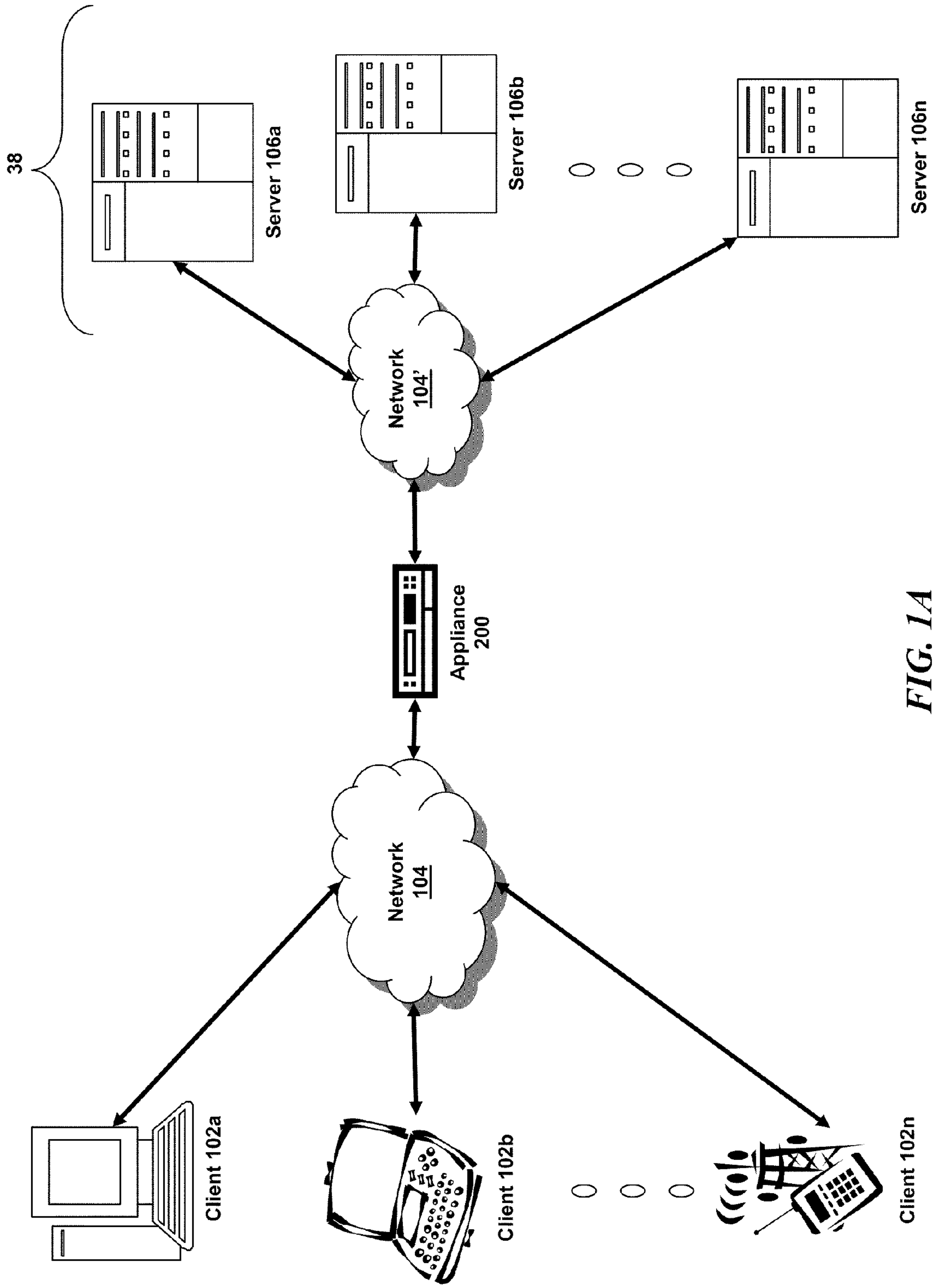

38
Server 106a
Server 106b
Server 106n
Network
104'
Appliance
200
Network
104
Client 102a
Client 102b
Client 102n

FIG. 1A

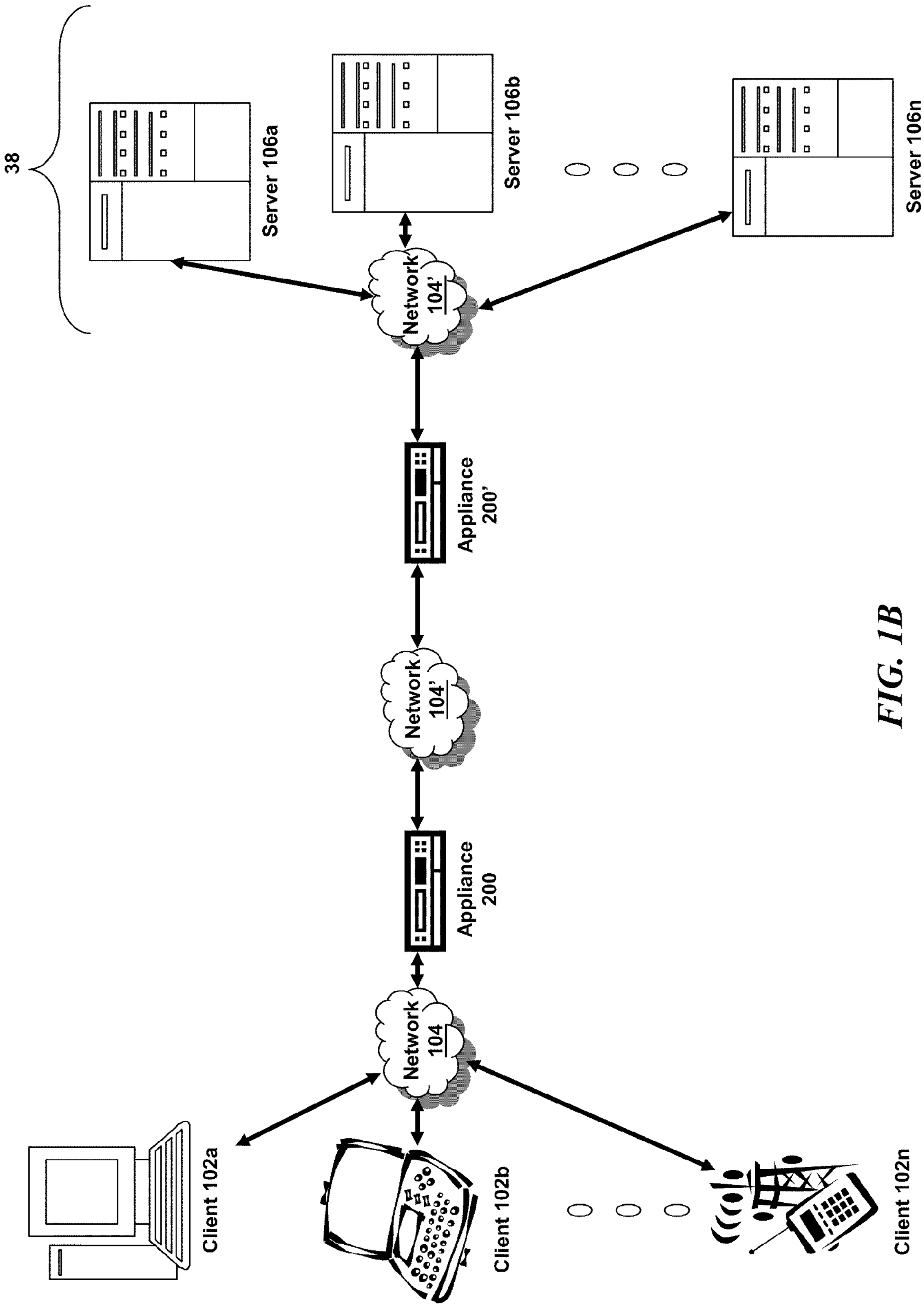

38
Server 106a
Server 106b
Server 106n
Network 104'
Appliance 200'
Network 104'
Appliance 200
Network 104
Client 102a
Client 102b
Client 102n

FIG. 1B

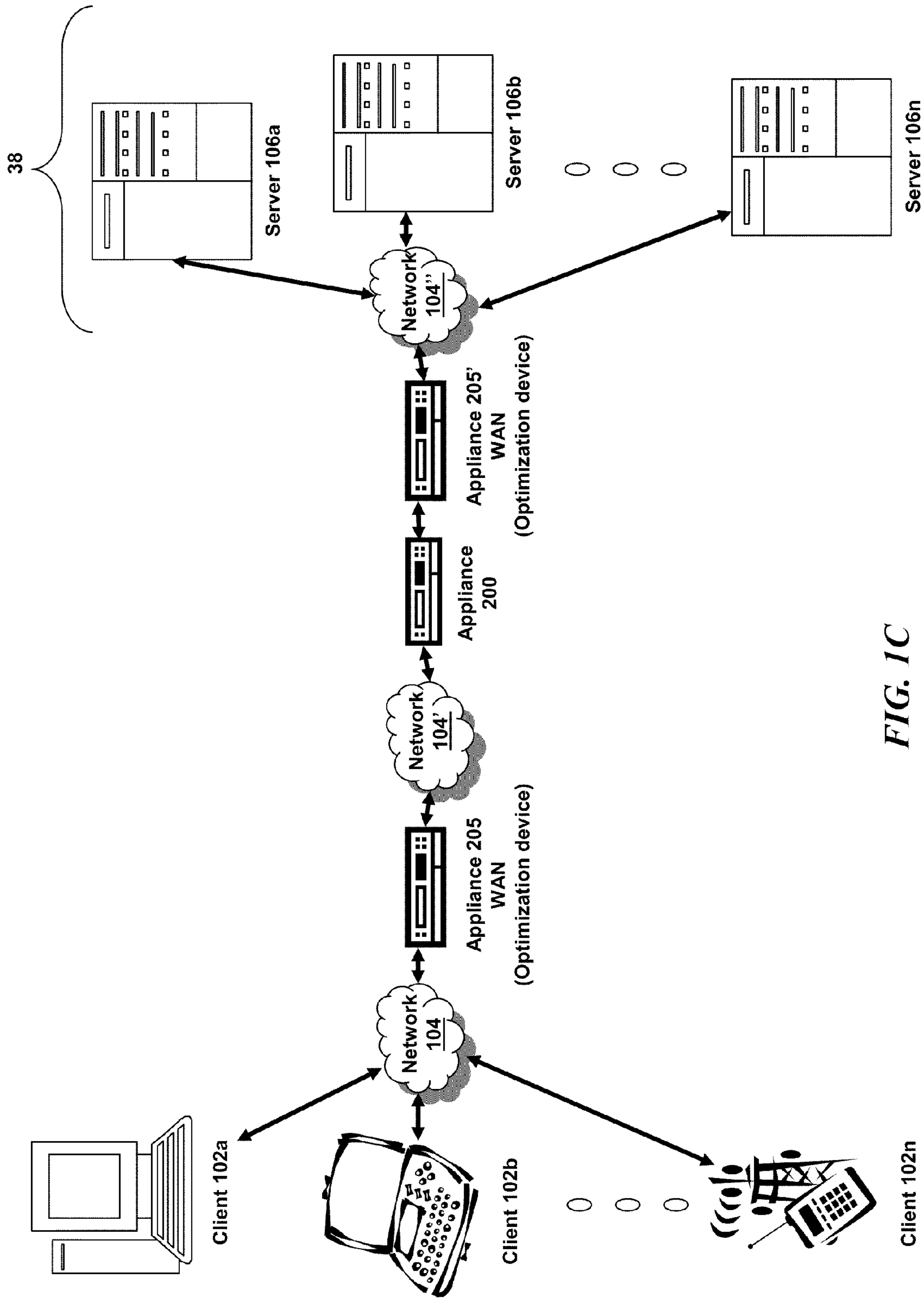

38
Server 106a
Server 106b
Server 106n
Network 104''
Appliance 205' WAN (Optimization device)
Appliance 200
Network 104'
Appliance 205 WAN (Optimization device)
Network 104
Client 102a
Client 102b
Client 102n

FIG. 1C

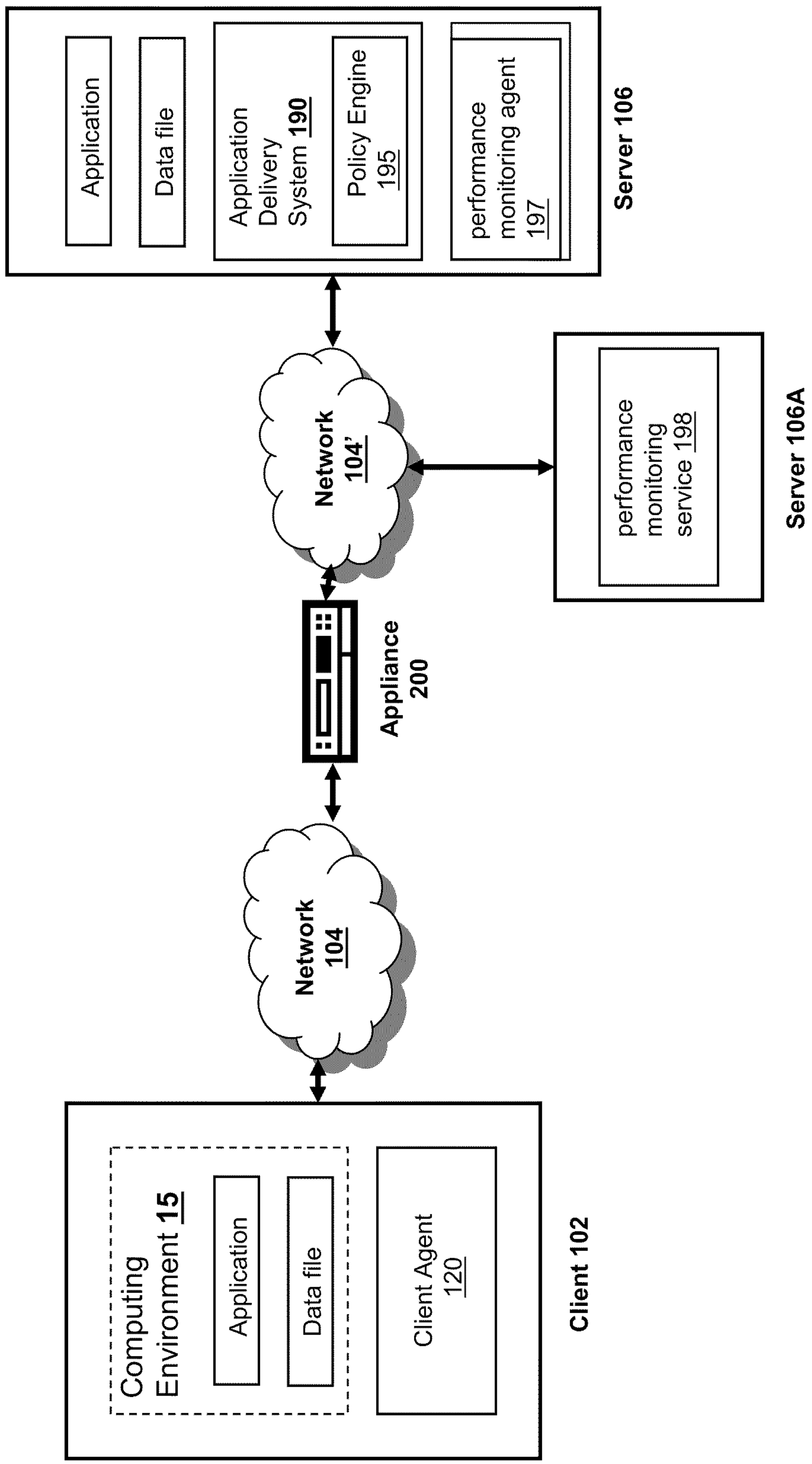

Application
Data file
Application Delivery System 190
Policy Engine 195
performance monitoring agent 197
Server 106
Network 104'
performance monitoring service 198
Server 106A
Appliance 200
Network 104
Computing Environment 15
Application
Data file
Client Agent 120
Client 102

FIG. 1D

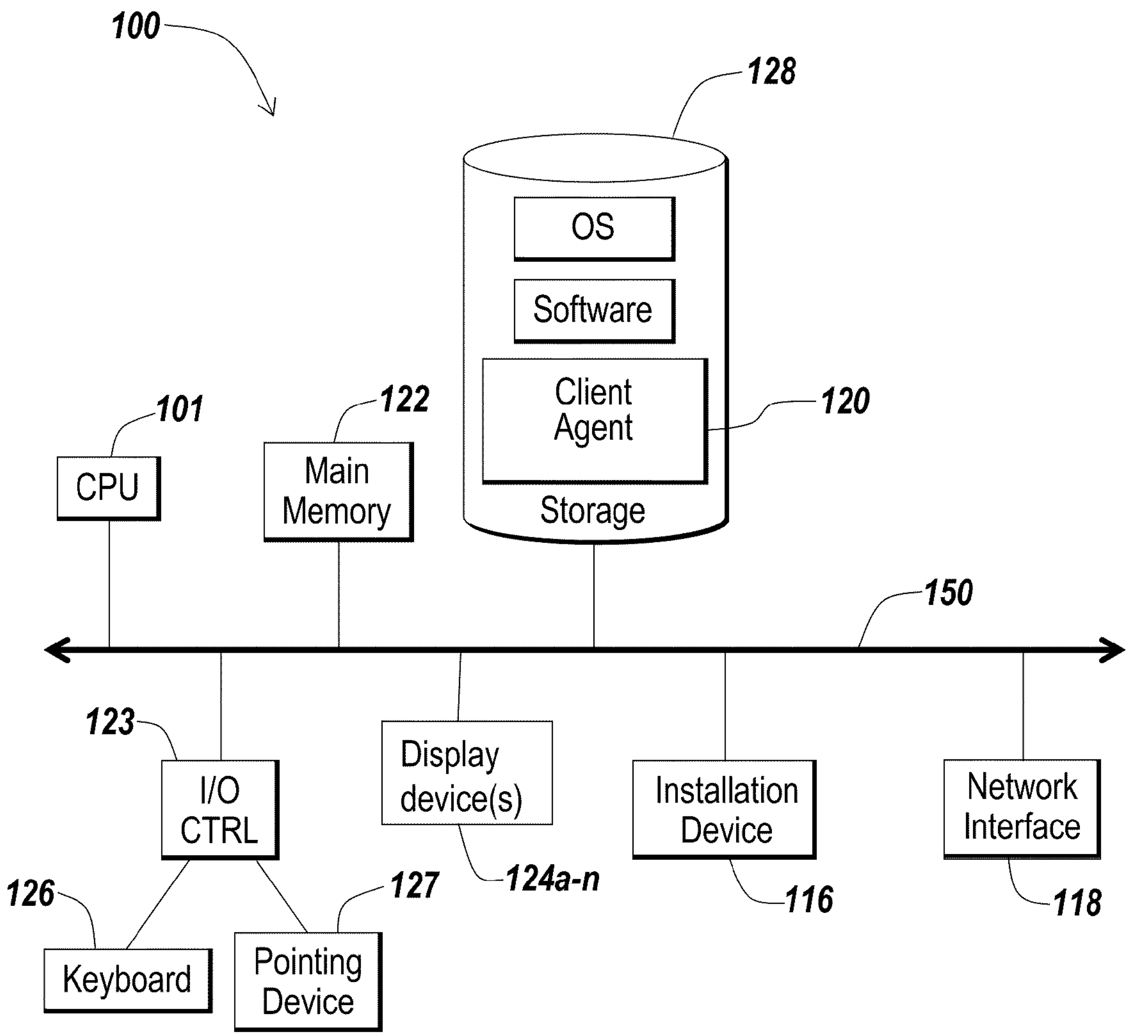

100
128
OS
Software
Client
Agent
120
Storage
101
CPU
122
Main
Memory
150
123
I/O
CTRL
Display
device(s)
124a-n
Installation
Device
116
Network
Interface
118
126
Keyboard
127
Pointing
Device

FIG. 1E

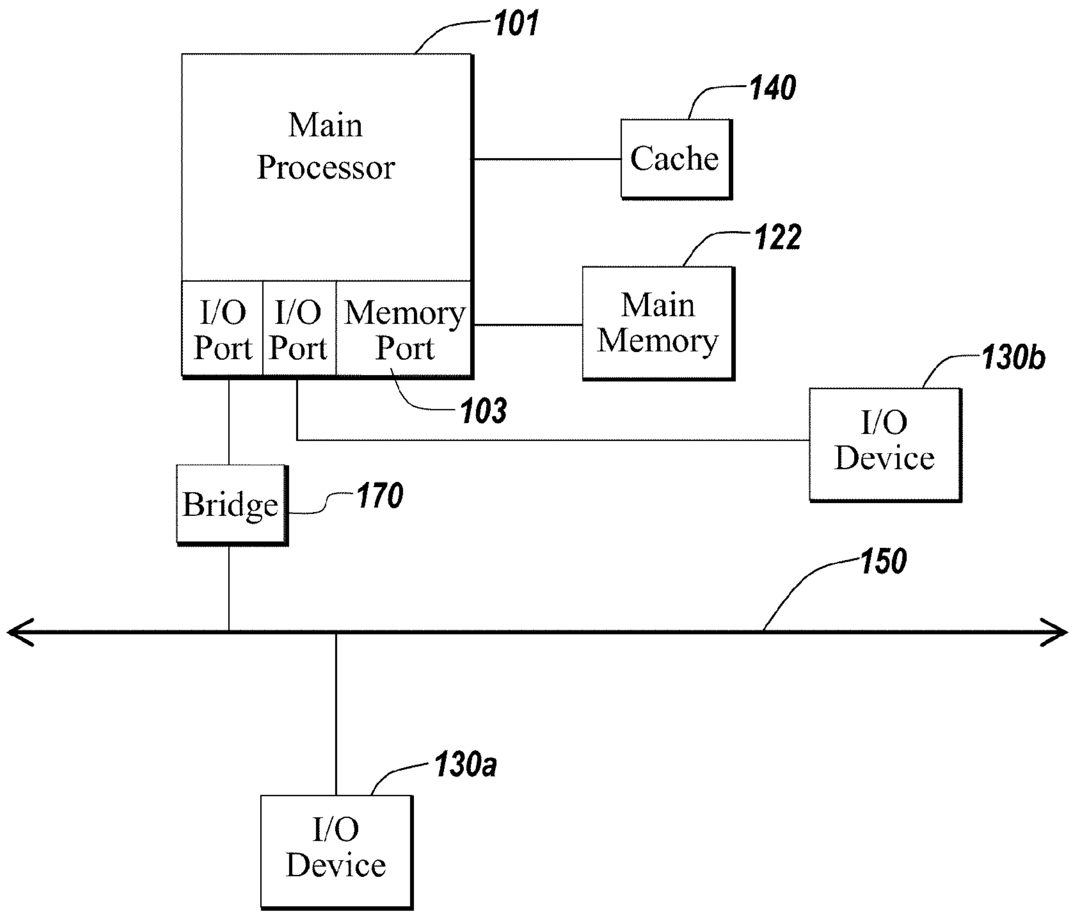

101
Main Processor
140
Cache
122
Main Memory
I/O Port
I/O Port
Memory Port
130b
I/O Device
103
Bridge
170
150
130a
I/O Device

FIG. 1F

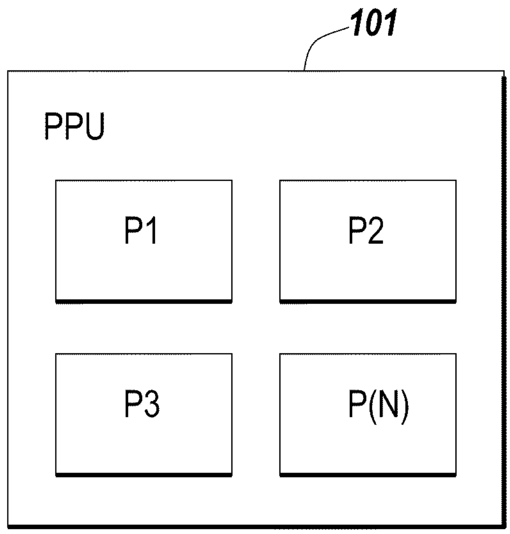


FIG. 1G

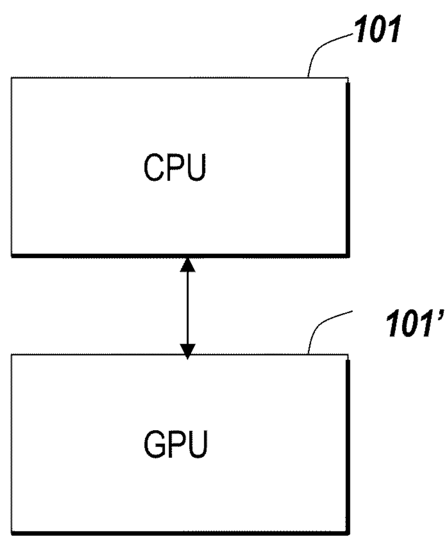
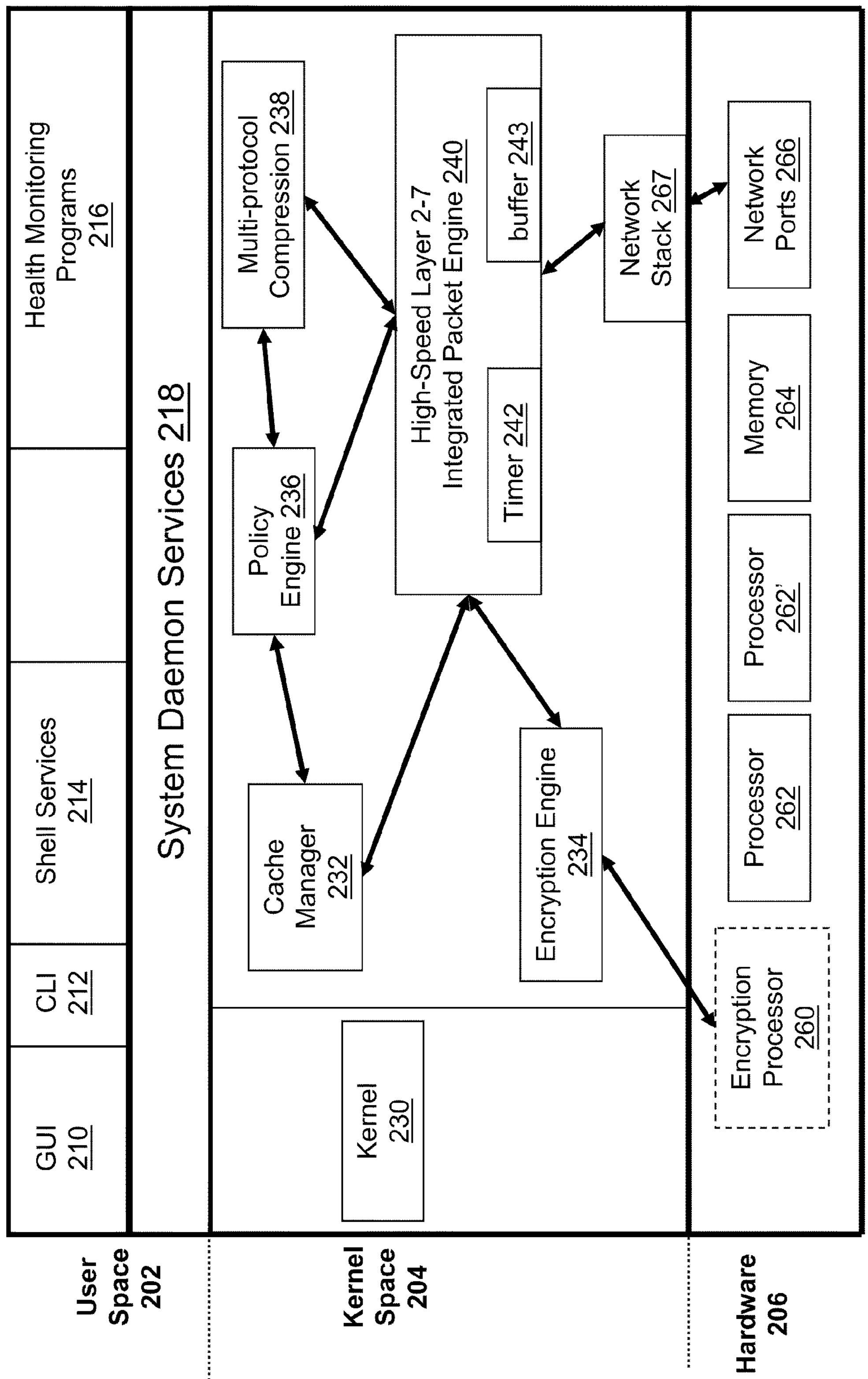


FIG. 1H



User Space 202
Kernel Space 204
Hardware 206
GUI 210
CLI 212
Shell Services 214
Health Monitoring Programs 216
System Daemon Services 218
Kernel 230
Cache Manager 232
Encryption Engine 234
Policy Engine 236
Multi-protocol Compression 238
High-Speed Layer 2-7 Integrated Packet Engine 240
Timer 242
buffer 243
Network Stack 267
Encryption Processor 260
Processor 262
Processor 262'
Memory 264
Network Ports 266
200

FIG. 2A

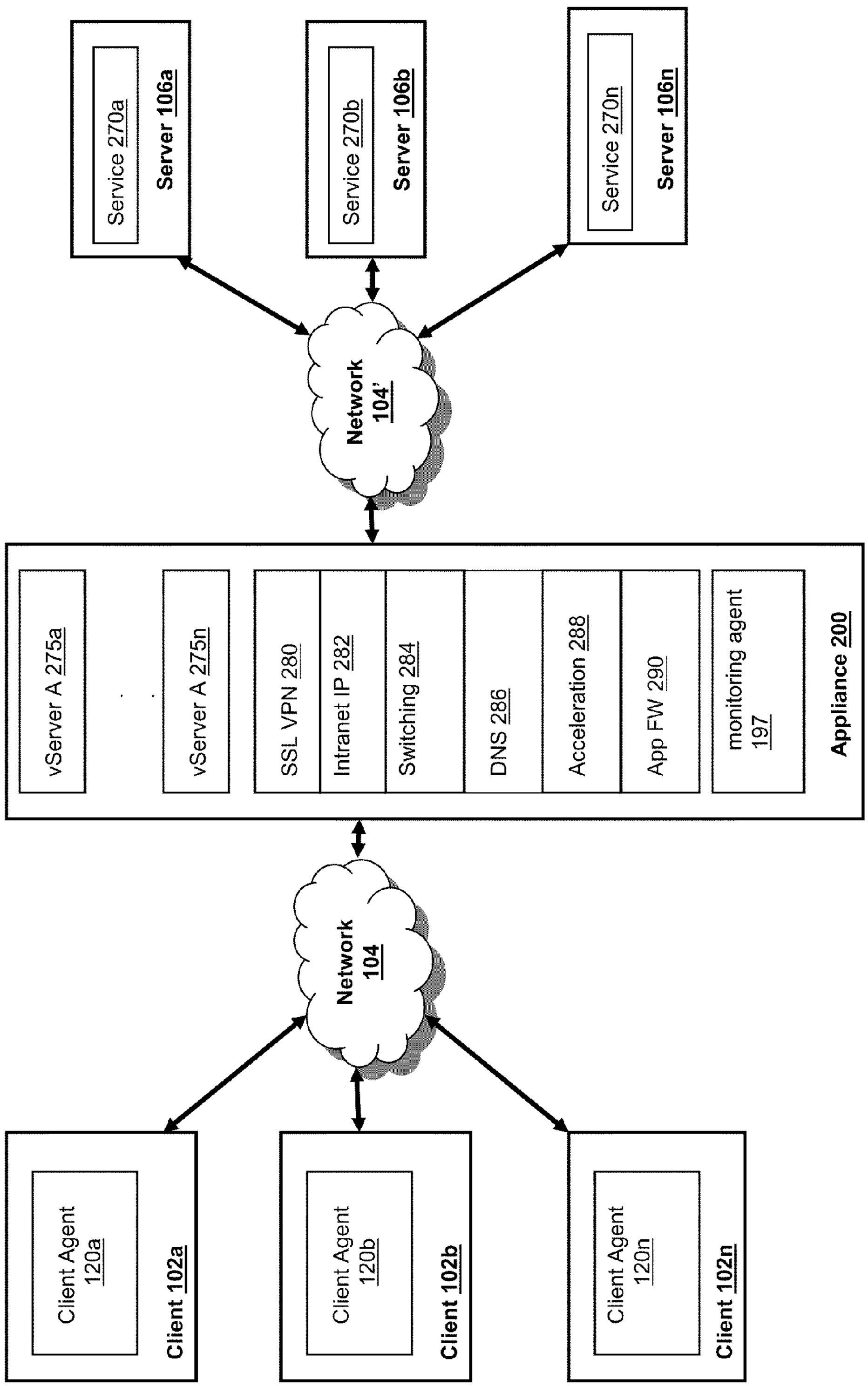

Service 270a
Server 106a
Service 270b
Server 106b
Service 270n
Server 106n
Network 104'
vServer A 275a
vServer A 275n
SSL VPN 280
Intranet IP 282
Switching 284
DNS 286
Acceleration 288
App FW 290
monitoring agent 197
Appliance 200
Network 104
Client Agent 120a
Client 102a
Client Agent 120b
Client 102b
Client Agent 120n
Client 102n

FIG. 2B

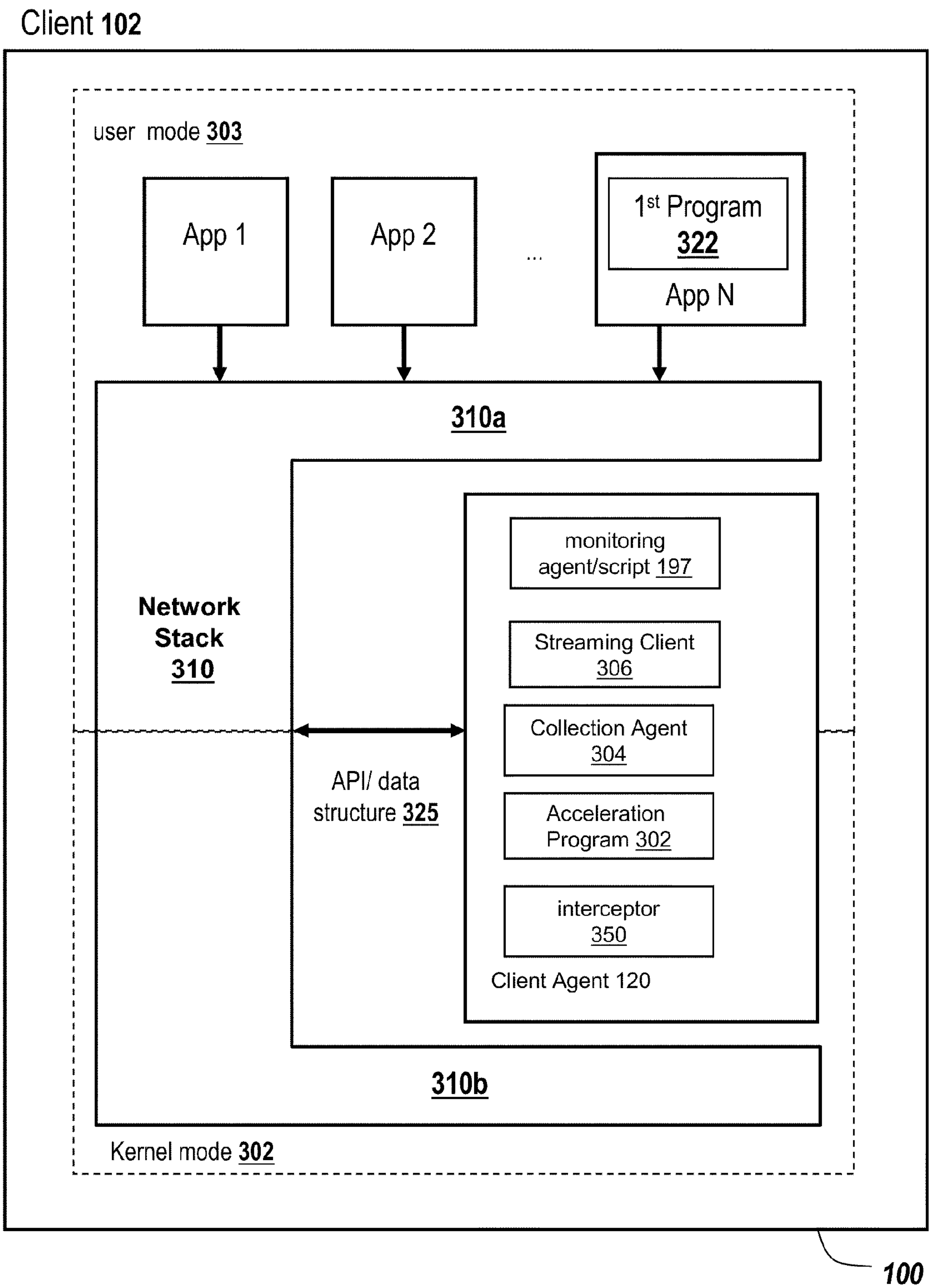

Client 102
user mode 303
App 1
App 2
...
1st Program
322
App N
310a
Network
Stack
310
monitoring
agent/script 197
Streaming Client
306
Collection Agent
304
Acceleration
Program 302
interceptor
350
Client Agent 120
API/ data
structure 325
310b
Kernel mode 302
100

FIG. 3

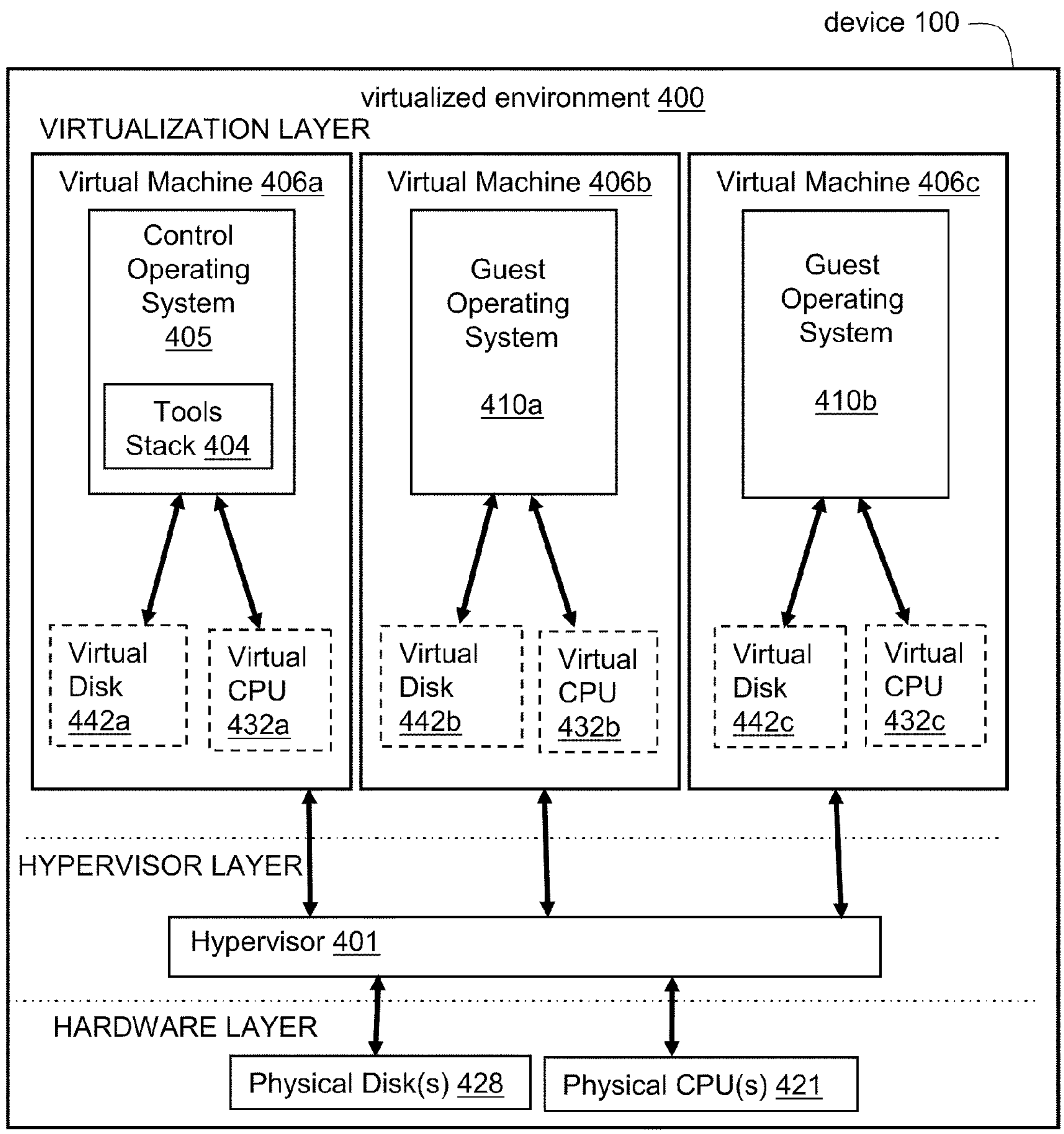

device 100
virtualized environment 400
VIRTUALIZATION LAYER
Virtual Machine 406a
Control Operating System 405
Tools Stack 404
Virtual Disk 442a
Virtual CPU 432a
Virtual Machine 406b
Guest Operating System 410a
Virtual Disk 442b
Virtual CPU 432b
Virtual Machine 406c
Guest Operating System 410b
Virtual Disk 442c
Virtual CPU 432c
HYPERVISOR LAYER
Hypervisor 401
HARDWARE LAYER
Physical Disk(s) 428
Physical CPU(s) 421

FIG. 4A

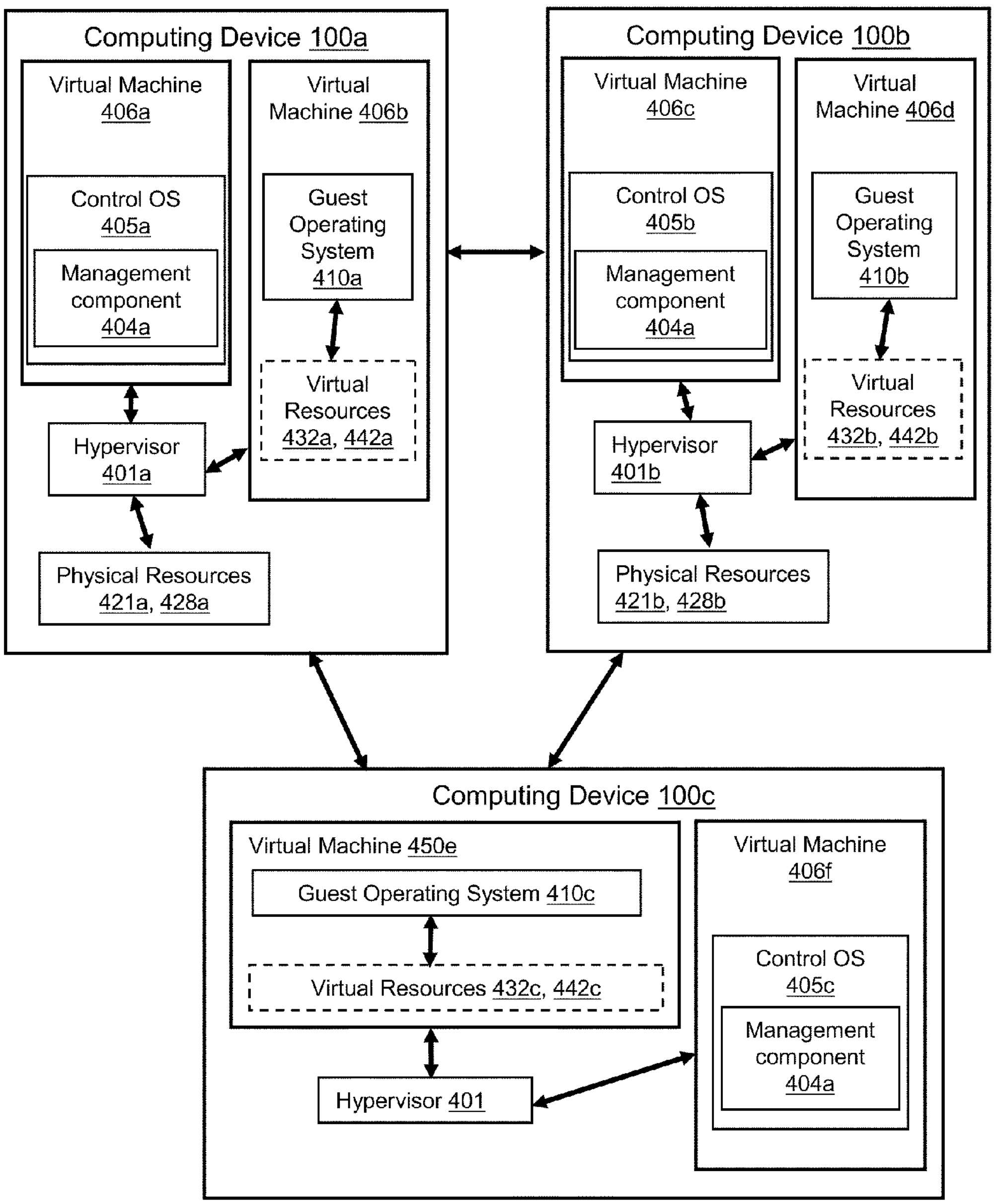

Computing Device 100a
Virtual Machine 406a
Control OS 405a
Management component 404a
Virtual Machine 406b
Guest Operating System 410a
Virtual Resources 432a, 442a
Hypervisor 401a
Physical Resources 421a, 428a
Computing Device 100b
Virtual Machine 406c
Control OS 405b
Management component 404a
Virtual Machine 406d
Guest Operating System 410b
Virtual Resources 432b, 442b
Hypervisor 401b
Physical Resources 421b, 428b
Computing Device 100c
Virtual Machine 450e
Guest Operating System 410c
Virtual Resources 432c, 442c
Hypervisor 401
Virtual Machine 406f
Control OS 405c
Management component 404a

FIG. 4B

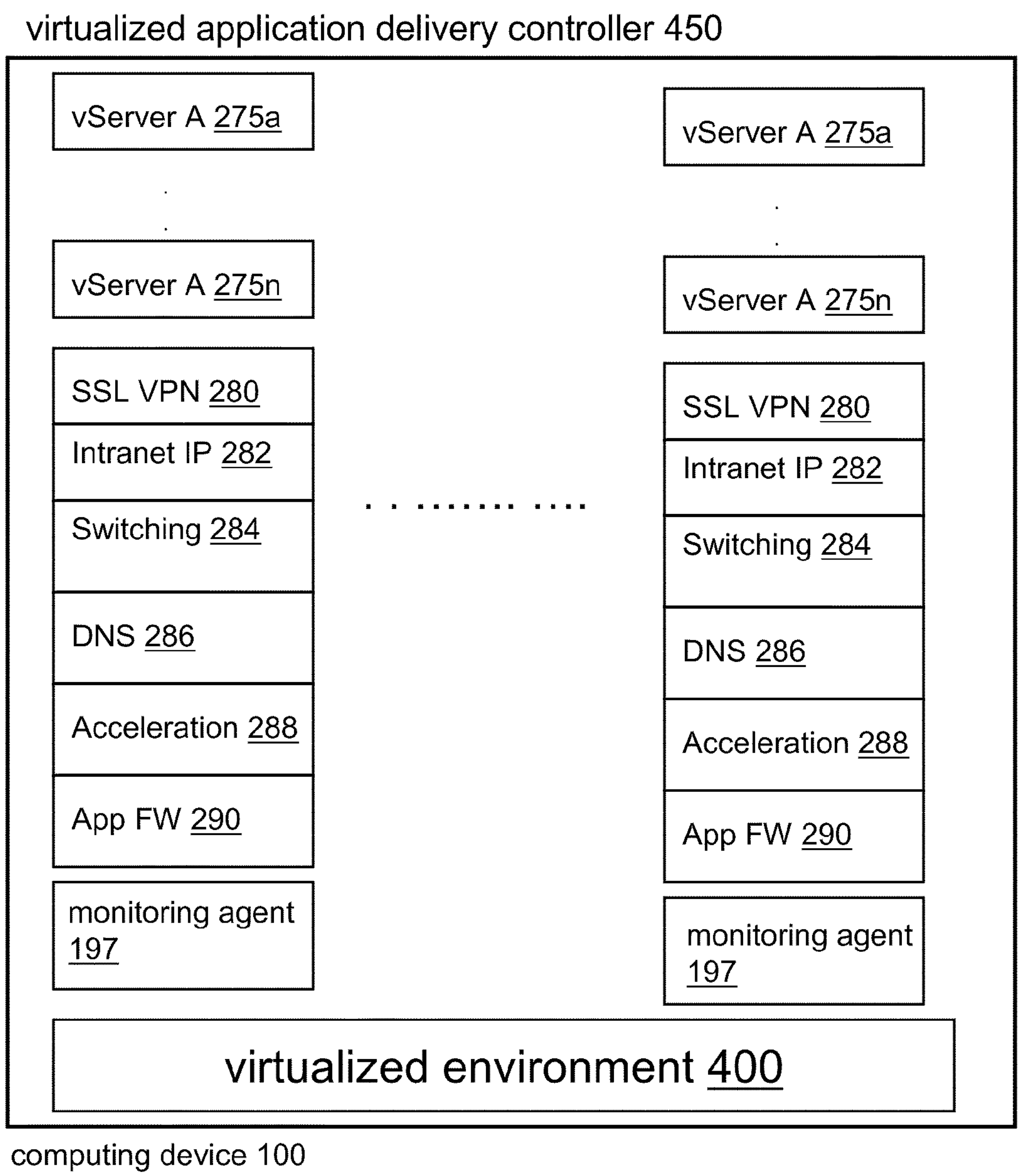

virtualized application delivery controller 450
vServer A 275a
vServer A 275n
SSL VPN 280
Intranet IP 282
Switching 284
DNS 286
Acceleration 288
App FW 290
monitoring agent 197
vServer A 275a
vServer A 275n
SSL VPN 280
Intranet IP 282
Switching 284
DNS 286
Acceleration 288
App FW 290
monitoring agent 197
virtualized environment 400
computing device 100

FIG. 4C

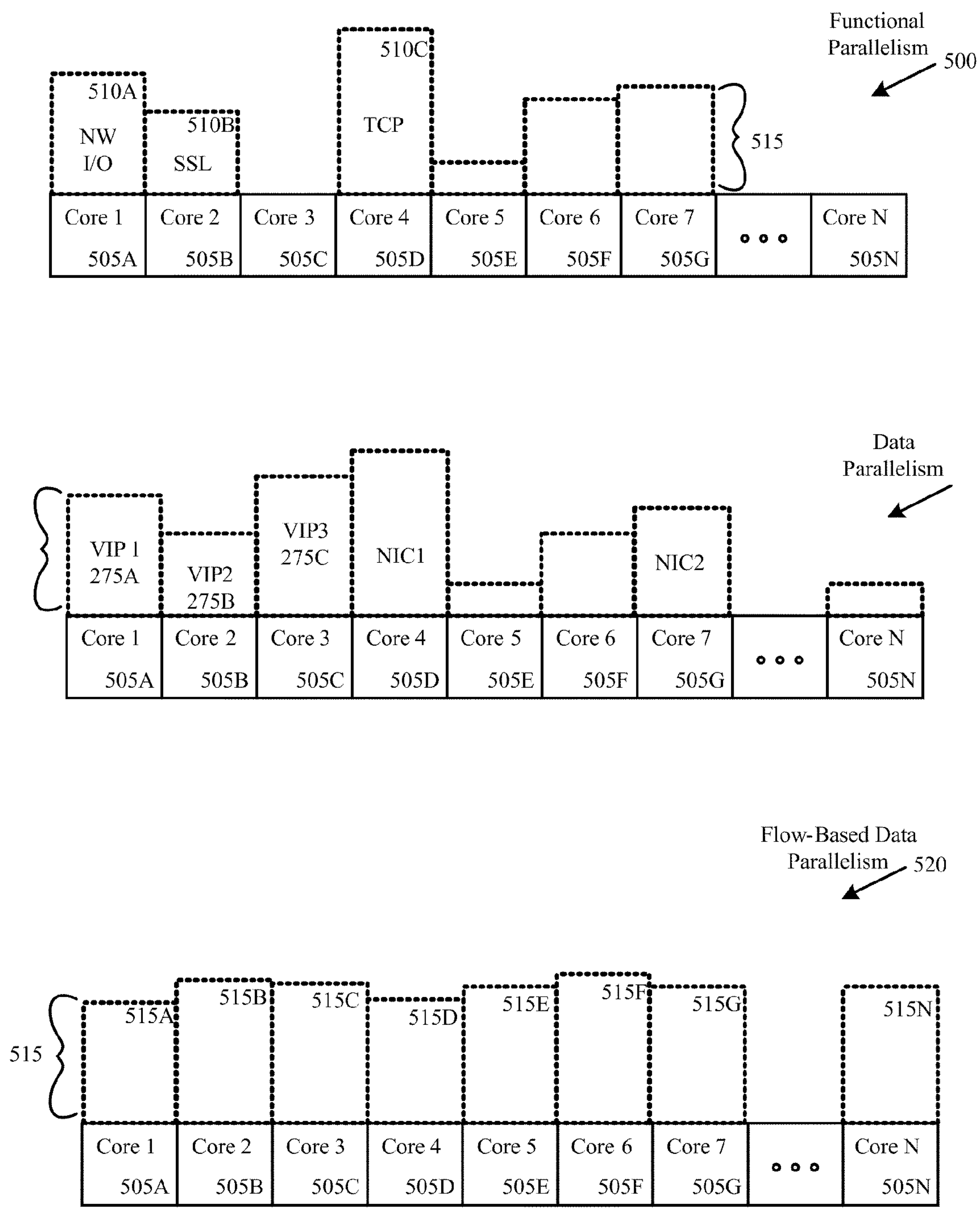

Functional Parallelism
500
510A
NW I/O
510B
SSL
510C
TCP
515
Core 1 505A
Core 2 505B
Core 3 505C
Core 4 505D
Core 5 505E
Core 6 505F
Core 7 505G
Core N 505N
Data Parallelism
VIP 1 275A
VIP2 275B
VIP3 275C
NIC1
NIC2
Core 1 505A
Core 2 505B
Core 3 505C
Core 4 505D
Core 5 505E
Core 6 505F
Core 7 505G
Core N 505N
Flow-Based Data Parallelism
520
515
515A
515B
515C
515D
515E
515F
515G
515N
Core 1 505A
Core 2 505B
Core 3 505C
Core 4 505D
Core 5 505E
Core 6 505F
Core 7 505G
Core N 505N

FIG. 5A

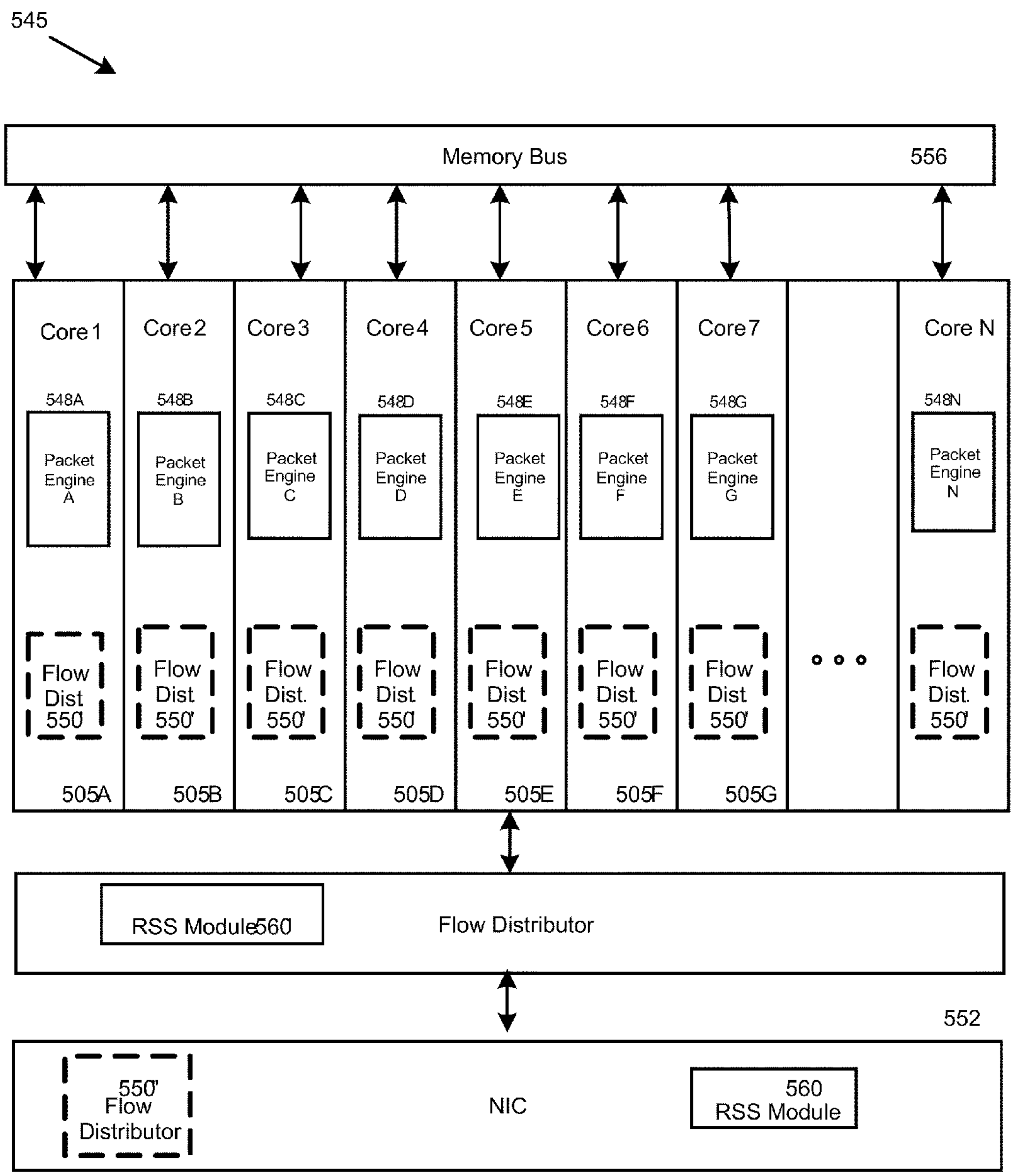

545
Memory Bus
556
Core 1
Core 2
Core 3
Core 4
Core 5
Core 6
Core 7
Core N
548A
548B
548C
548D
548E
548F
548G
548N
Packet Engine A
Packet Engine B
Packet Engine C
Packet Engine D
Packet Engine E
Packet Engine F
Packet Engine G
Packet Engine N
Flow Dist 550'
Flow Dist 550'
Flow Dist. 550'
Flow Dist 550'
Flow Dist 550'
Flow Dist. 550'
Flow Dist 550'
Flow Dist. 550'
505A
505B
505C
505D
505E
505F
505G
RSS Module 560
Flow Distributor
552
550' Flow Distributor
NIC
560 RSS Module

FIG. 5B

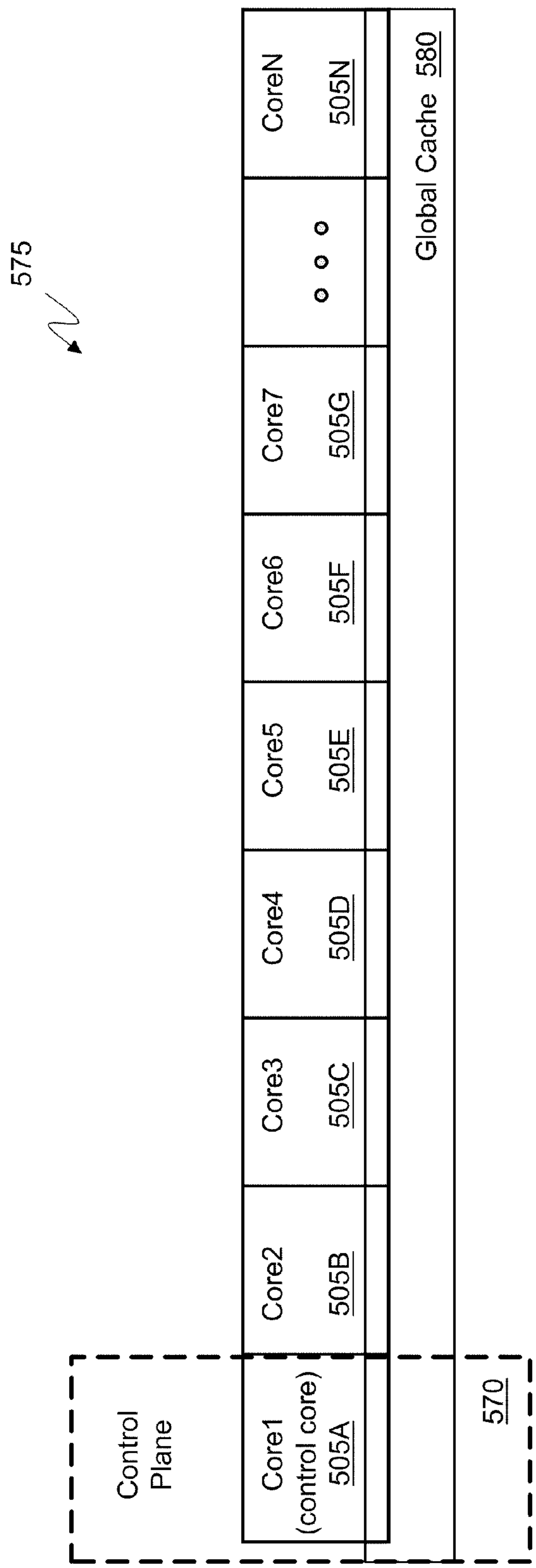
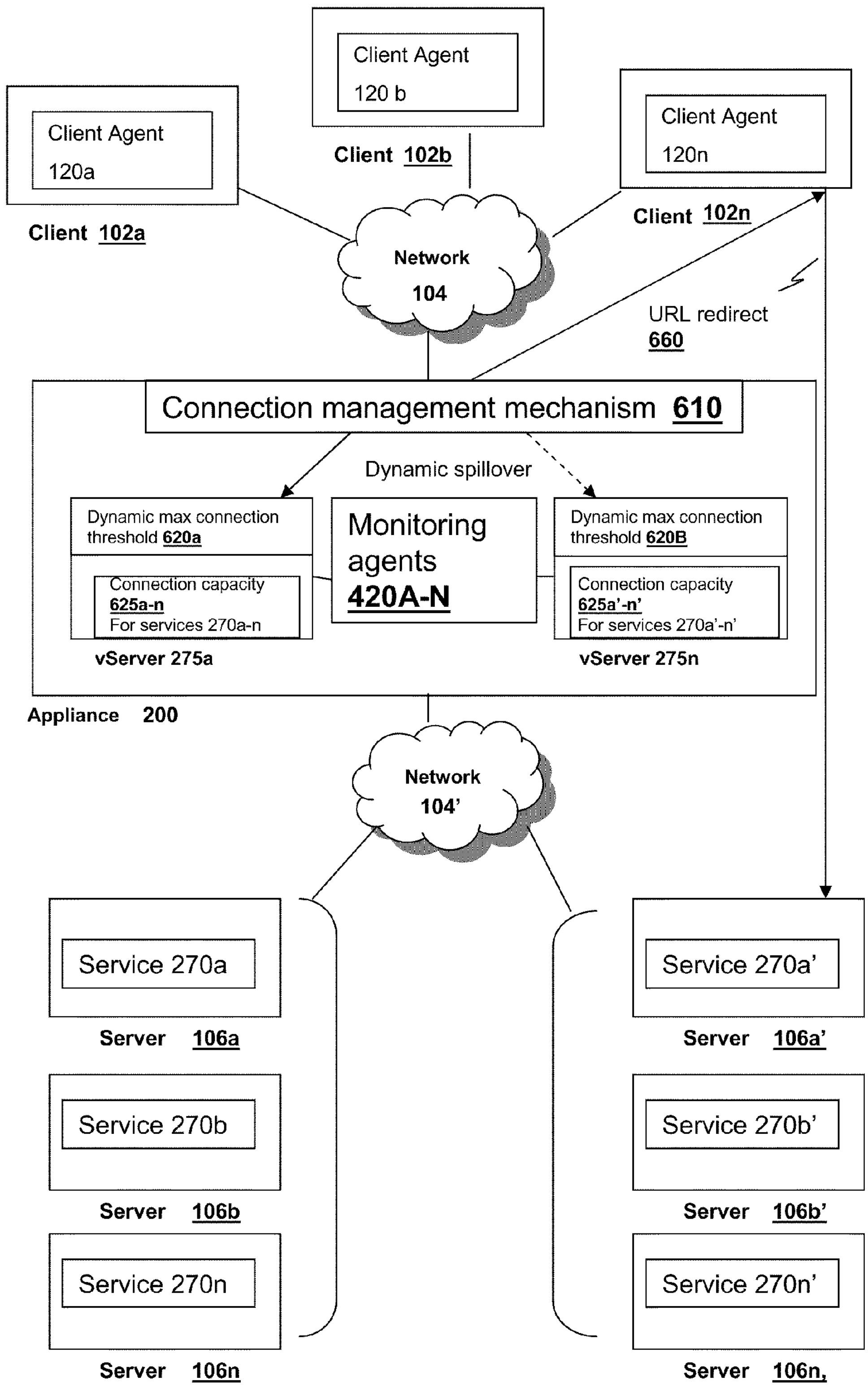

575
Control Plane
Core1 (control core) 505A
Core2 505B
Core3 505C
Core4 505D
Core5 505E
Core6 505F
Core7 505G
CoreN 505N
Global Cache 580
570

FIG. 5C



Client Agent
120 b
Client 102b
Client Agent
120a
Client 102a
Client Agent
120n
Client 102n
Network
104
URL redirect
660
Connection management mechanism 610
Dynamic spillover
Dynamic max connection threshold 620a
Connection capacity 625a-n
For services 270a-n
Monitoring agents 420A-N
Dynamic max connection threshold 620B
Connection capacity 625a'-n'
For services 270a'-n'
vServer 275a
vServer 275n
Appliance 200
Network
104'
Service 270a
Server 106a
Service 270b
Server 106b
Service 270n
Server 106n
Service 270a'
Server 106a'
Service 270b'
Server 106b'
Service 270n'
Server 106n,

Fig. 6

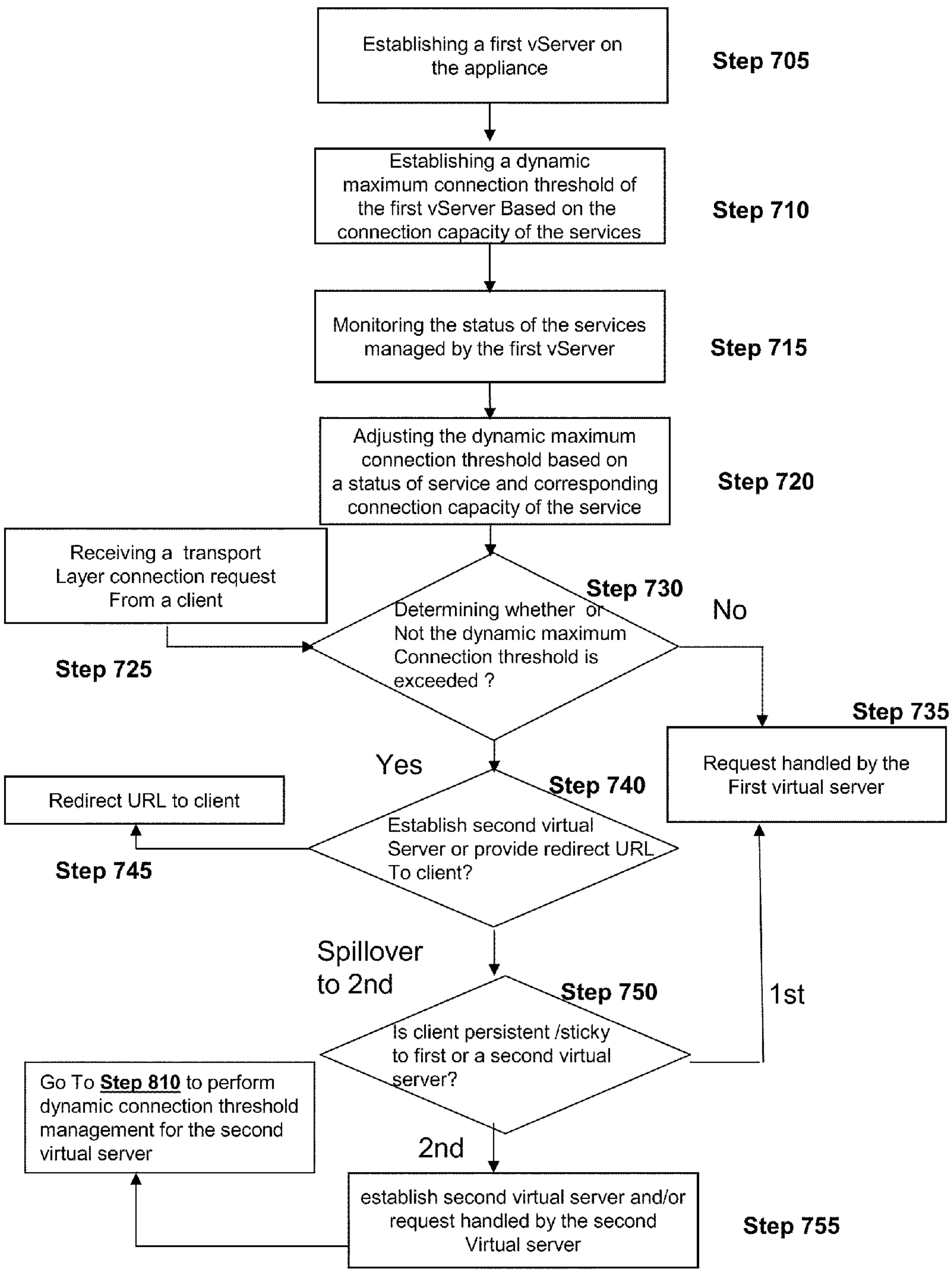
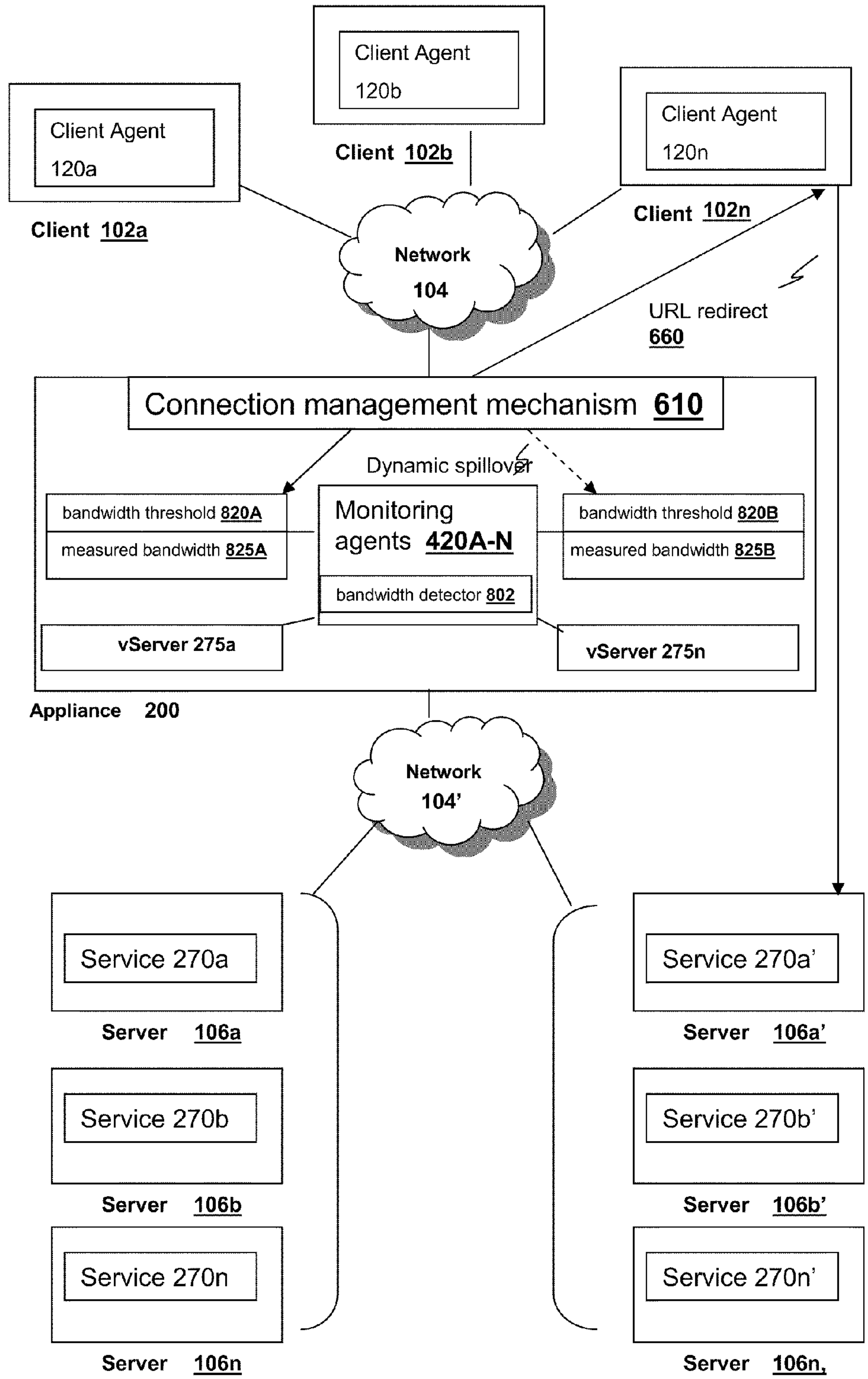
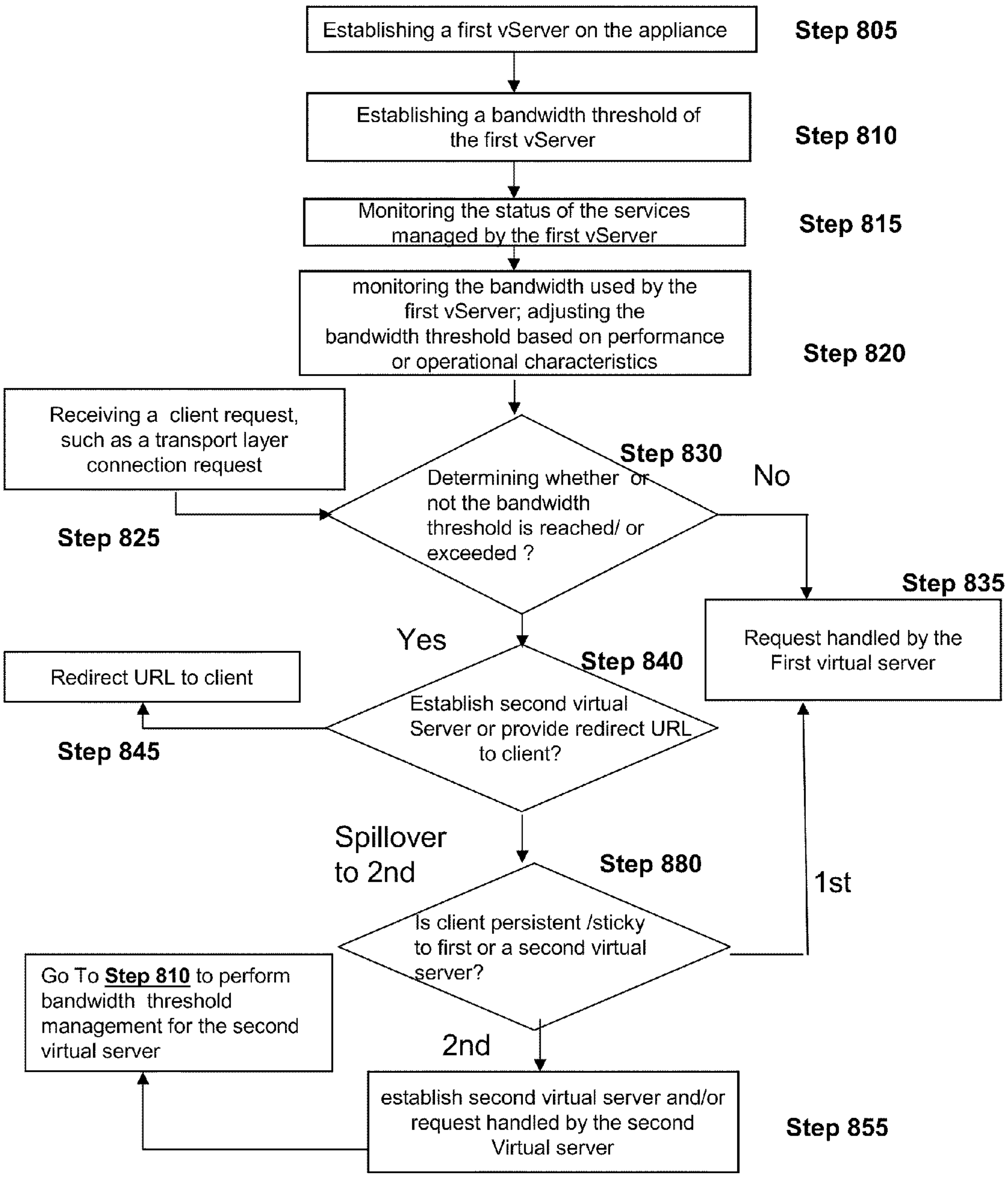

Establishing a first vServer on the appliance
Step 705
Establishing a dynamic maximum connection threshold of the first vServer Based on the connection capacity of the services
Step 710
Monitoring the status of the services managed by the first vServer
Step 715
Adjusting the dynamic maximum connection threshold based on a status of service and corresponding connection capacity of the service
Step 720
Receiving a transport Layer connection request From a client
Step 725
Step 730
Determining whether or Not the dynamic maximum Connection threshold is exceeded ?
No
Step 735
Request handled by the First virtual server
Yes
Step 740
Redirect URL to client
Establish second virtual Server or provide redirect URL To client?
Step 745
Spillover to 2nd
Step 750
1st
Is client persistent /sticky to first or a second virtual server?
Go To Step 810 to perform dynamic connection threshold management for the second virtual server
2nd
establish second virtual server and/or request handled by the second Virtual server
Step 755

Fig. 7



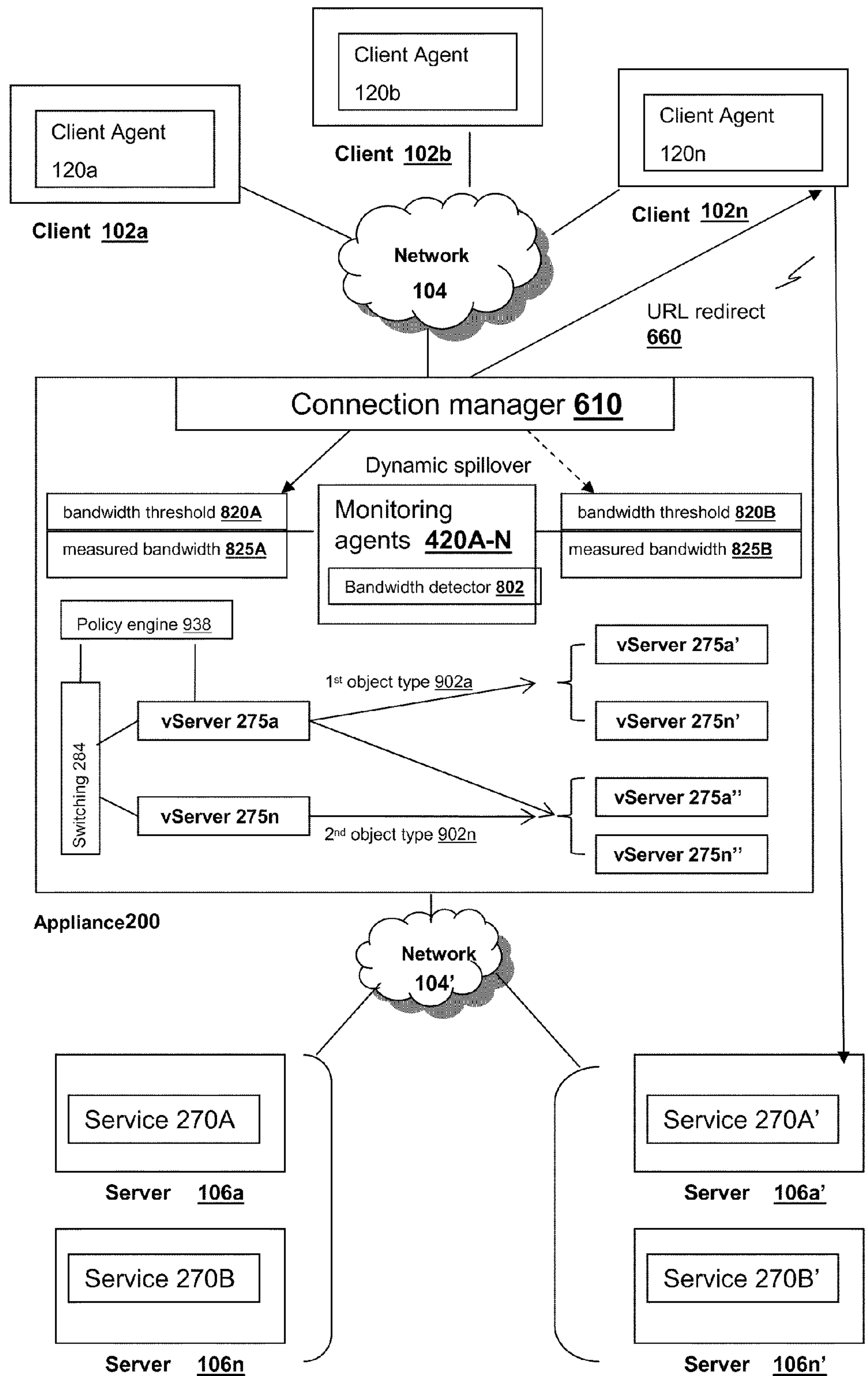
Client Agent
120b
Client 102b
Client Agent
120a
Client 102a
Client Agent
120n
Client 102n
Network
104
URL redirect
660
Connection management mechanism 610
Dynamic spillover
bandwidth threshold 820A
measured bandwidth 825A
Monitoring agents 420A-N
bandwidth detector 802
bandwidth threshold 820B
measured bandwidth 825B
vServer 275a
vServer 275n
Appliance 200
Network
104'
Service 270a
Server 106a
Service 270b
Server 106b
Service 270n
Server 106n
Service 270a'
Server 106a'
Service 270b'
Server 106b'
Service 270n'
Server 106n,

Fig. 8A



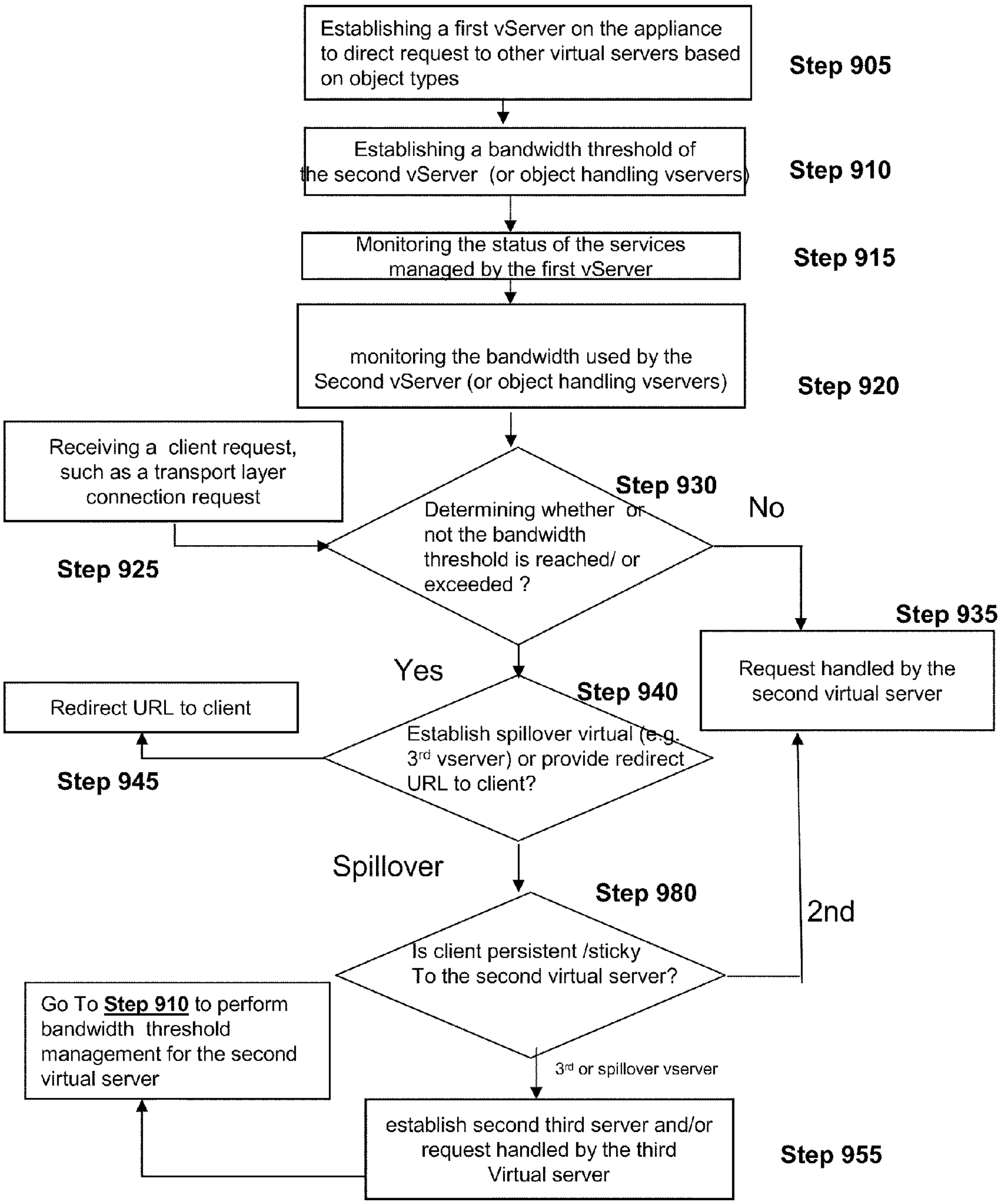
Establishing a first vServer on the appliance
Step 805
Establishing a bandwidth threshold of the first vServer
Step 810
Monitoring the status of the services managed by the first vServer
Step 815
monitoring the bandwidth used by the first vServer; adjusting the bandwidth threshold based on performance or operational characteristics
Step 820
Receiving a client request, such as a transport layer connection request
Step 825
Determining whether or not the bandwidth threshold is reached/ or exceeded ?
Step 830
No
Step 835
Request handled by the First virtual server
Yes
Step 840
Redirect URL to client
Establish second virtual Server or provide redirect URL to client?
Step 845
Spillover to 2nd
Step 880
1st
Is client persistent /sticky to first or a second virtual server?
Go To Step 810 to perform bandwidth threshold management for the second virtual server
2nd
establish second virtual server and/or request handled by the second Virtual server
Step 855

Fig. 8B



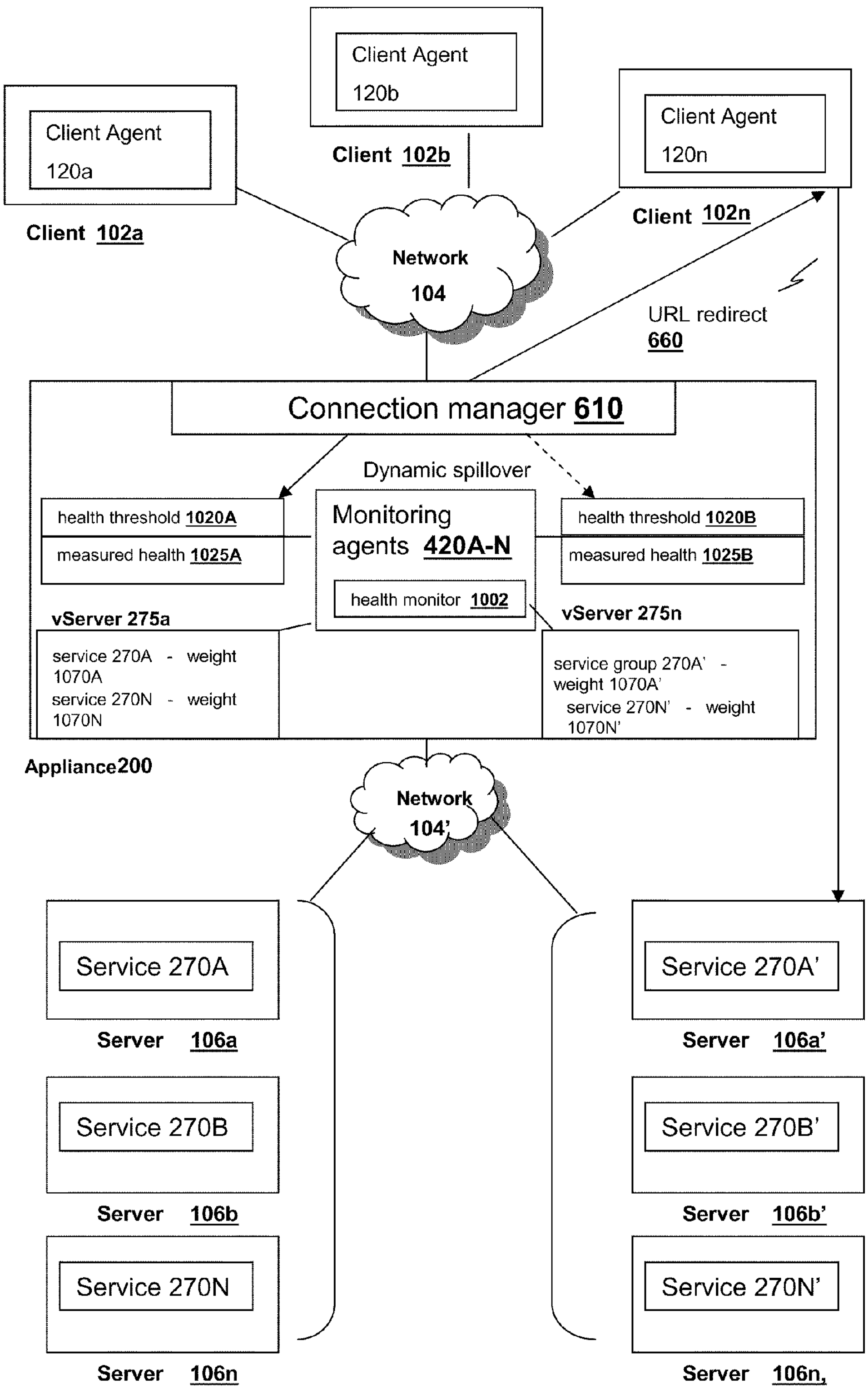
Client Agent
120b
Client 102b
Client Agent
120a
Client 102a
Client Agent
120n
Client 102n
Network
104
URL redirect
660
Connection manager 610
Dynamic spillover
bandwidth threshold 820A
measured bandwidth 825A
Monitoring agents 420A-N
Bandwidth detector 802
bandwidth threshold 820B
measured bandwidth 825B
Policy engine 938
vServer 275a'
1st object type 902a
vServer 275n'
vServer 275a
Switching 284
vServer 275a''
vServer 275n
2nd object type 902n
vServer 275n''
Appliance200
Network
104'
Service 270A
Server 106a
Service 270B
Server 106n
Service 270A'
Server 106a'
Service 270B'
Server 106n'

Fig. 9A



Establishing a first vServer on the appliance to direct request to other virtual servers based on object types
Step 905
Establishing a bandwidth threshold of the second vServer (or object handling vservers)
Step 910
Monitoring the status of the services managed by the first vServer
Step 915
monitoring the bandwidth used by the Second vServer (or object handling vservers)
Step 920
Receiving a client request, such as a transport layer connection request
Step 925
Step 930
Determining whether or not the bandwidth threshold is reached/ or exceeded ?
No
Step 935
Request handled by the second virtual server
Yes
Step 940
Redirect URL to client
Establish spillover virtual (e.g. 3rd vserver) or provide redirect URL to client?
Step 945
Spillover
Step 980
2nd
Is client persistent /sticky To the second virtual server?
Go To Step 910 to perform bandwidth threshold management for the second virtual server
3rd or spillover vserver
establish second third server and/or request handled by the third Virtual server
Step 955

Fig. 9B



Client Agent
120b
Client 102b
Client Agent
120a
Client 102a
Client Agent
120n
Client 102n
Network
104
URL redirect
660
Connection manager 610
Dynamic spillover
health threshold 1020A
measured health 1025A
Monitoring agents 420A-N
health monitor 1002
health threshold 1020B
measured health 1025B
vServer 275a
service 270A - weight 1070A
service 270N - weight 1070N
vServer 275n
service group 270A' - weight 1070A'
service 270N' - weight 1070N'
Appliance200
Network
104'
Service 270A
Server 106a
Service 270B
Server 106b
Service 270N
Server 106n
Service 270A'
Server 106a'
Service 270B'
Server 106b'
Service 270N'
Server 106n,

Fig. 10A

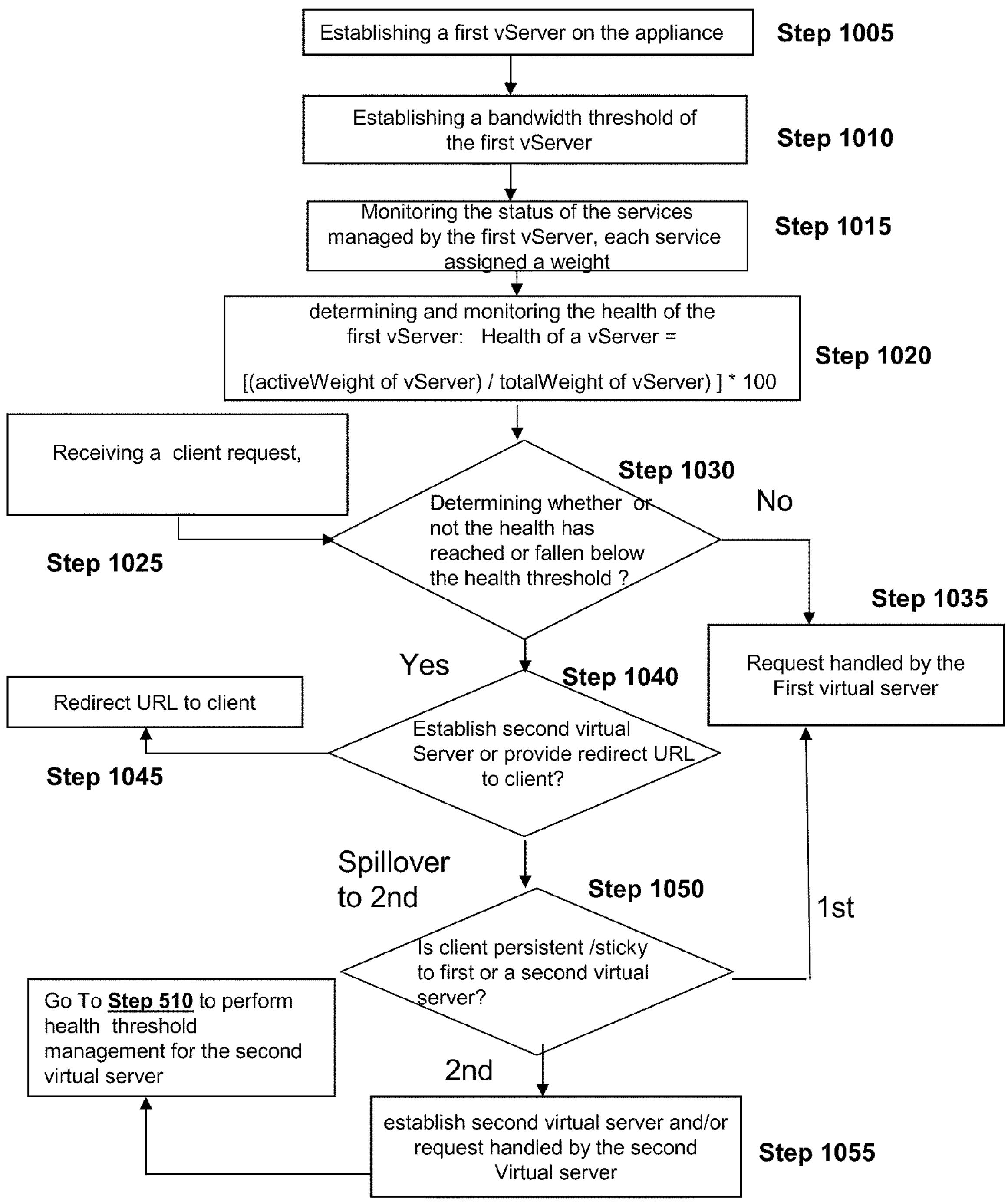
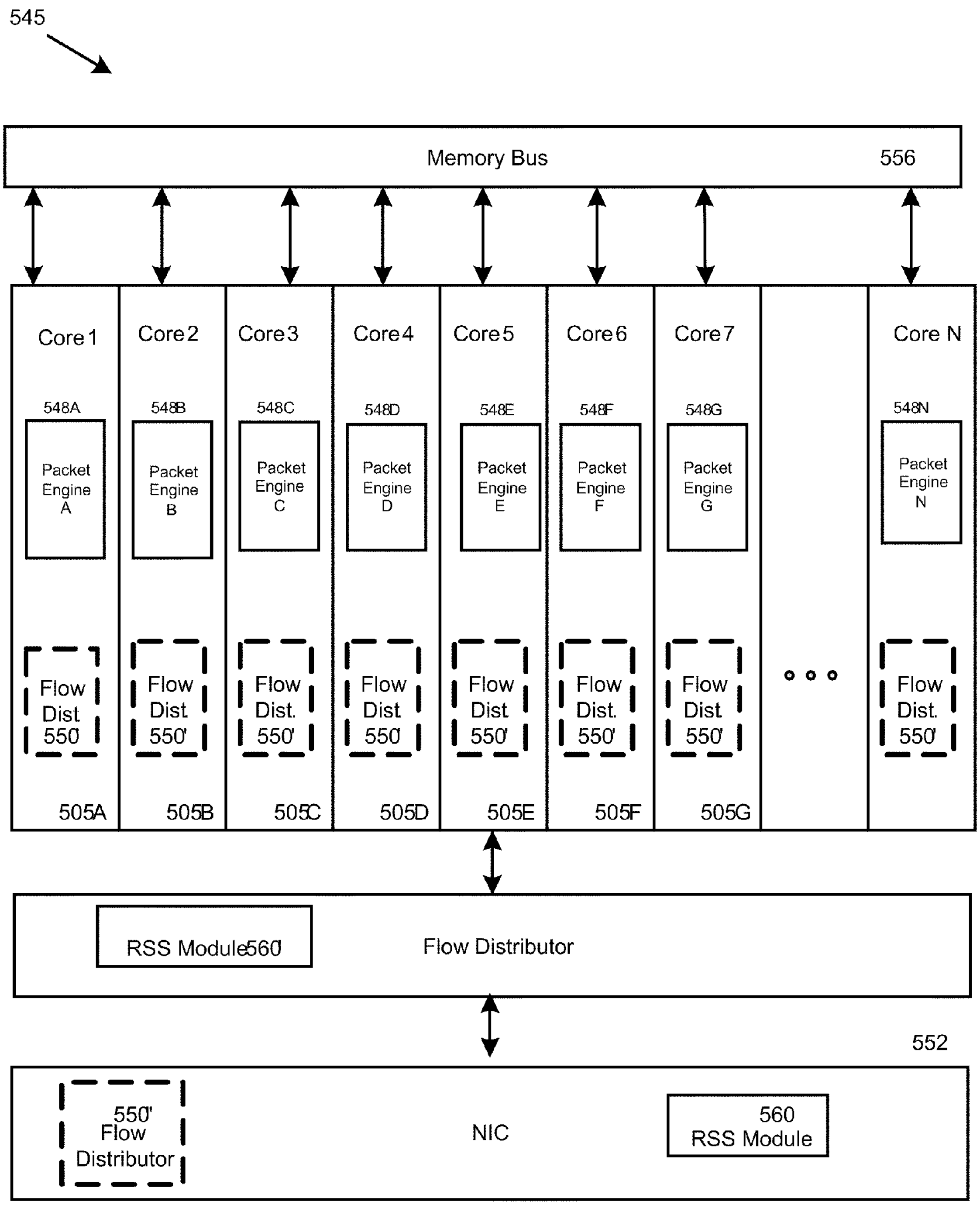

Establishing a first vServer on the appliance
Step 1005
Establishing a bandwidth threshold of the first vServer
Step 1010
Monitoring the status of the services managed by the first vServer, each service assigned a weight
Step 1015
determining and monitoring the health of the first vServer: Health of a vServer =
[(activeWeight of vServer) / totalWeight of vServer)] * 100
Step 1020
Receiving a client request,
Step 1025
Step 1030
Determining whether or not the health has reached or fallen below the health threshold ?
No
Step 1035
Request handled by the First virtual server
Yes
Step 1040
Redirect URL to client
Establish second virtual Server or provide redirect URL to client?
Step 1045
Spillover to 2nd
Step 1050
1st
Is client persistent /sticky to first or a second virtual server?
Go To Step 510 to perform health threshold management for the second virtual server
2nd
establish second virtual server and/or request handled by the second Virtual server
Step 1055

Fig. 10B



545
Memory Bus
556
Core 1
Core 2
Core 3
Core 4
Core 5
Core 6
Core 7
Core N
548A
548B
548C
548D
548E
548F
548G
548N
Packet Engine A
Packet Engine B
Packet Engine C
Packet Engine D
Packet Engine E
Packet Engine F
Packet Engine G
Packet Engine N
Flow Dist 550
Flow Dist 550'
Flow Dist. 550'
Flow Dist 550
Flow Dist 550'
Flow Dist. 550'
Flow Dist 550'
Flow Dist. 550'
505A
505B
505C
505D
505E
505F
505G
RSS Module 560
Flow Distributor
552
550' Flow Distributor
NIC
560 RSS Module

FIG. 11

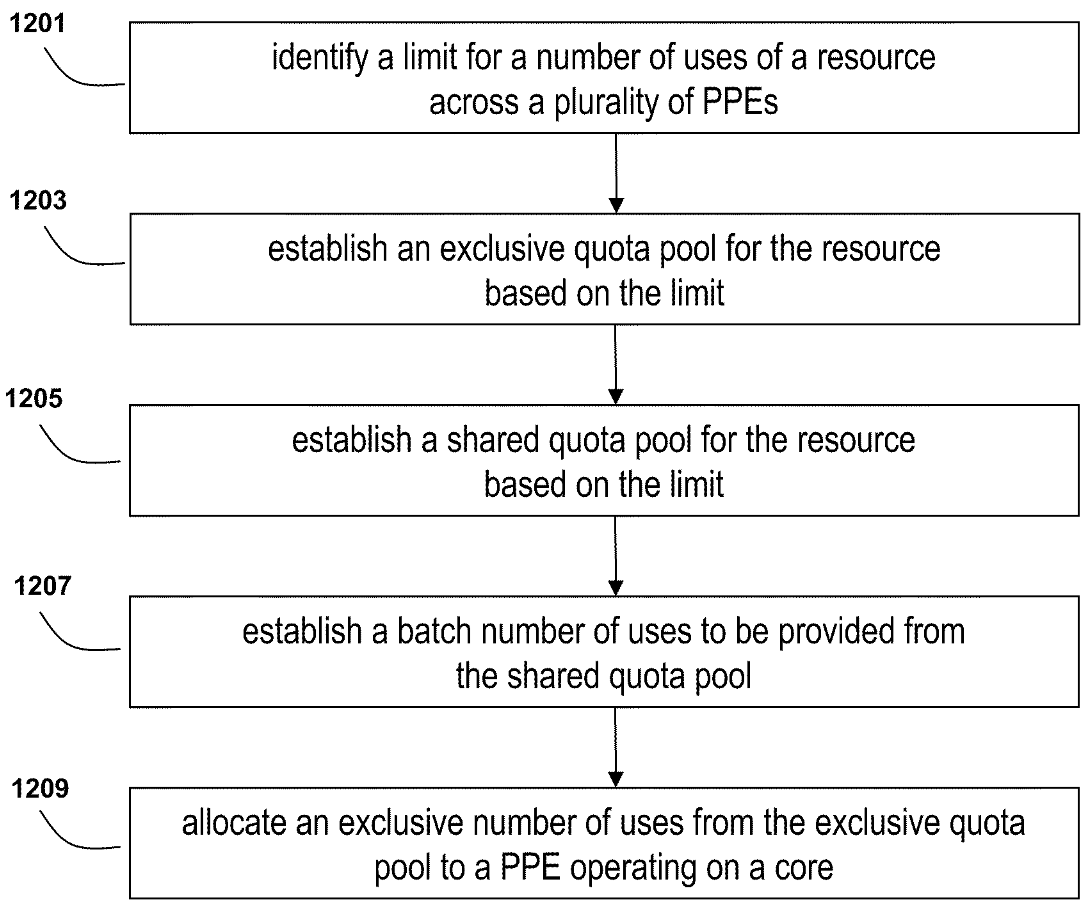

1201
identify a limit for a number of uses of a resource across a plurality of PPEs
1203
establish an exclusive quota pool for the resource based on the limit
1205
establish a shared quota pool for the resource based on the limit
1207
establish a batch number of uses to be provided from the shared quota pool
1209
allocate an exclusive number of uses from the exclusive quota pool to a PPE operating on a core

FIG. 12A

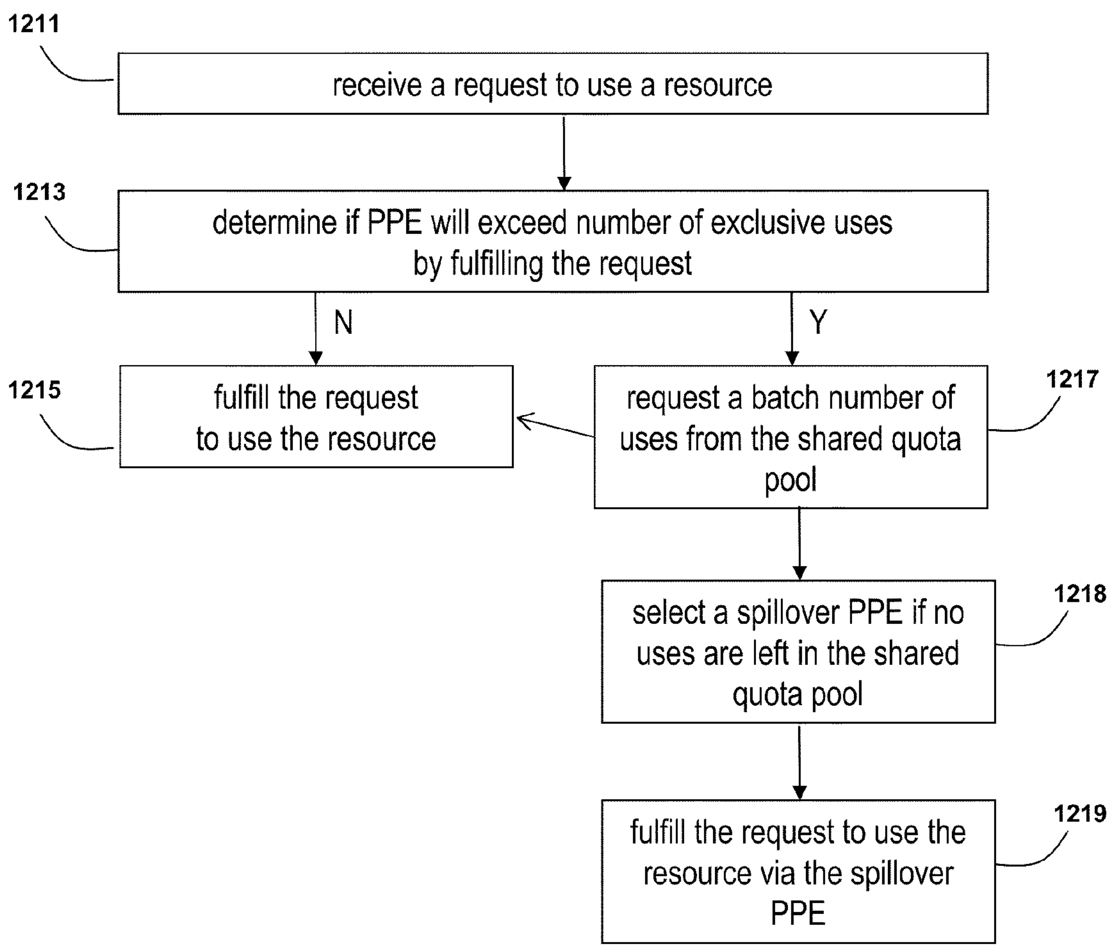

1211
receive a request to use a resource
1213
determine if PPE will exceed number of exclusive uses by fulfilling the request
N
Y
1215
fulfill the request to use the resource
request a batch number of uses from the shared quota pool
1217
select a spillover PPE if no uses are left in the shared quota pool
1218
fulfill the request to use the resource via the spillover PPE
1219

FIG. 12B

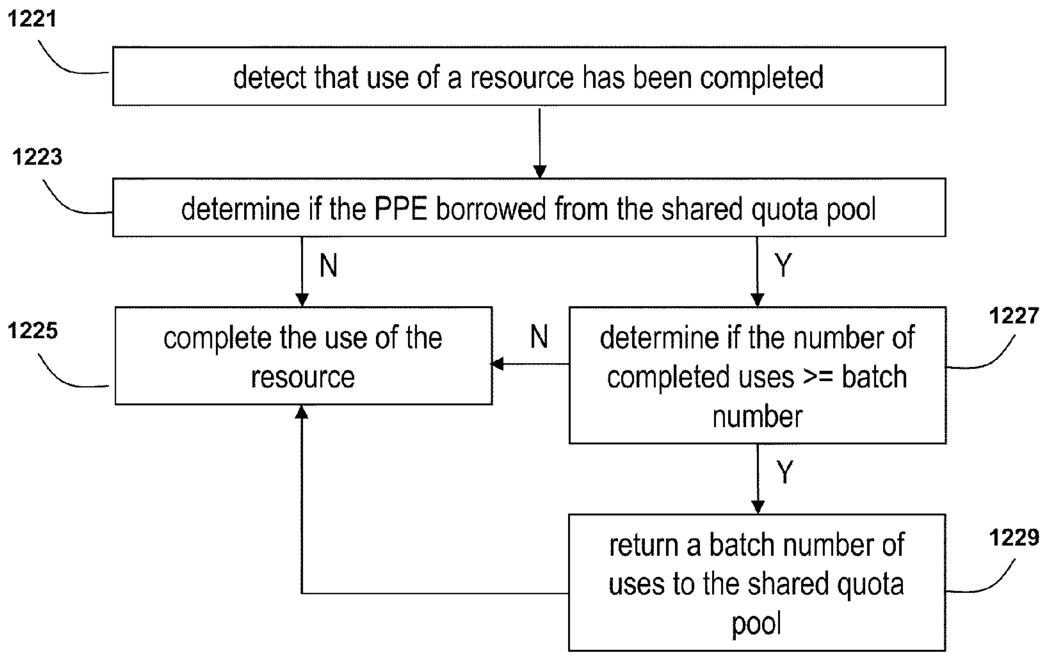

1221
detect that use of a resource has been completed
1223
determine if the PPE borrowed from the shared quota pool
N
Y
1225
complete the use of the resource
N
determine if the number of completed uses >= batch number
1227
Y
return a batch number of uses to the shared quota pool
1229

FIG. 12C

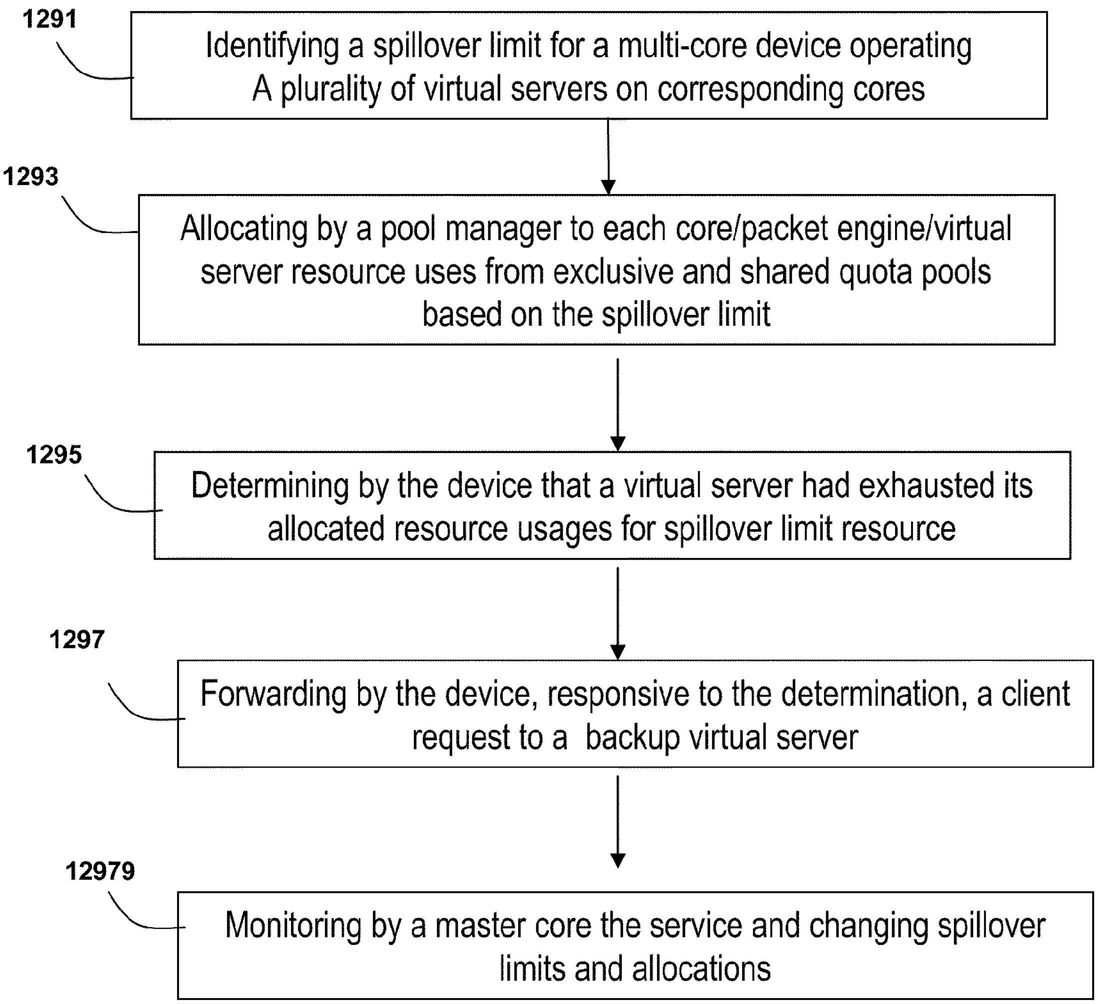

1291
Identifying a spillover limit for a multi-core device operating A plurality of virtual servers on corresponding cores
1293
Allocating by a pool manager to each core/packet engine/virtual server resource uses from exclusive and shared quota pools based on the spillover limit
1295
Determining by the device that a virtual server had exhausted its allocated resource usages for spillover limit resource
1297
Forwarding by the device, responsive to the determination, a client request to a backup virtual server
12979
Monitoring by a master core the service and changing spillover limits and allocations

FIG. 12D

SYSTEMS AND METHODS FOR MANAGING SPILLOVER LIMITS IN A MULTI-CORE SYSTEM

RELATED APPLICATION

The present application claims the benefit of and priority to U.S. Provisional Application No. 61/289,536, entitled "Systems and Methods For Managing Spillover Limits In A Multi-Core System" and filed on Dec. 23, 2009, which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

The present application generally relates to data communication networks. In particular, the present application relates to systems and methods for handling spillover in conjunction with limit parameters across cores in a multi-core system.

BACKGROUND OF THE INVENTION

As any resource possesses finite capacity, use of a resource over a network will be subject to inherent or imposed limits. In a single processor system, the processor may field all of these requests to use a resource. The processor may process multiple uses of the resource in parallel according to the processor's own capacity. In a multi-core system, requests to use the resource may be handled by different cores at different times. Each of the cores may be running at different capacity. It is challenging to manage the use of the resource across the different cores.

BRIEF SUMMARY OF THE INVENTION

The present application is directed towards handling limit parameters for spillover conditions of virtual servers across multiple cores in a multi-core system. In general overview, a limit parameter for a resource may indicate the maximum number of uses for the resource. A pool manager may manage this number of uses for the resource. The pool manager may determine an exclusive quota pool and a shared quota pool from the limit. The pool manager may allocate to each packet processing engine operating on a core of the multi-core system an exclusive number of uses from the exclusive quota pool. Each packet processing engine may use the resource up to the exclusive number of uses, without further restrictions. If a packet processing engine wishes to use the resource beyond its exclusive number, the packet processing engine may borrow uses from the shared quota pool. When the packet processing engine completes uses of the resource, the packet processing engine may return uses to the shared quota pool. However, if the packet processing engine may not borrow uses from the shared quota pool, the engine may spillover into another engine that is not using all of its exclusive uses.

In some aspects, the present disclosure is related to a method of managing spillover via a plurality of cores of a multi-core device intermediary to a plurality of clients and one or more services. The method includes identifying, for a device intermediary to a plurality of clients and one or more services, a spillover limit of a resource. The device may includes a plurality of virtual servers operating on a corresponding core of a plurality of cores of the device. The method further includes allocating, by a pool manager of the device, to each of the plurality of virtual servers, a number of resource uses from an exclusive quota pool and shared quota pool based on the spillover limit The device may determine that the number of resources used by a virtual server of the plurality of virtual servers has reached the allocated number of resource uses of the virtual server, and responsive to the determination, forwarding o a backup virtual server a request of a client of the plurality of clients received by the device for the virtual server.

In some embodiments, the method includes identifying for the device the spillover limit as a maximum number of connections to a service of the one or more services. In the embodiments, the method includes identifying for the device the spillover limit as a dynamic connection threshold, the dynamic connection threshold determined from a sum of a connection capacity of each of the plurality of virtual servers. In some embodiments, the method includes identifying for the device the spillover limit as a bandwidth threshold.

In some embodiments, the method includes allocating, by the pool manager, the number of resource uses comprising a number of exclusive uses from the exclusive quota pool and a number of non-exclusive uses from the shared quota pool. In some embodiments, the method includes requesting, by the virtual server, a resource use from the pool manager upon reaching the virtual server's allocation of resource uses. In some embodiments, the method includes determining, by the device, that the number of resource uses available from the pool manager for the virtual server has been exhausted. In some embodiments, the method includes changing the spillover limit to a lower number of resource uses and responsive to the change the one or more of the plurality of virtual servers returning a portion of the allocated number of resource uses to the pool manager. In some embodiments, the method includes changing the spillover limit to a higher number of resource uses and responsive to the change, one or more the plurality of virtual servers requesting from the pool manager an additional the number of resource uses. In some embodiments, the method includes designating a first core of the plurality of cores as spillover master for monitoring the service and changing the spillover limit based on monitoring.

In some aspects, the present disclosure is directed to a system for managing spillover via a plurality of cores of a multi-core device intermediary to a plurality of clients and one or more services. The system may include a device intermediary to a plurality of clients and one or more services. The system may include a spillover limit of a resource. The device may also include a plurality of packet engines operating on a corresponding core of a plurality of cores of the device. The system may include a pool manager allocating to each of the plurality of packet engines a number of resource uses from an exclusive quota pool and shared quota pool based on the spillover limit. The device may also include a virtual server of a packet engine of the plurality of packet engines. The virtual server manages client requests to one or more services. The device determines that the number of resources used by a packet engine of the plurality of packet engine has reached the allocated number of resource uses of the packet engine, and responsive to the determination, forwards to a backup virtual server a request of a client of the plurality of clients received by the device for the virtual server.

In some embodiments, the device identifies the spillover limit as a maximum number of connections to a service of the one or more services. In some embodiments, the device identifies the spillover limit as a dynamic connection threshold, the dynamic connection threshold determined from a sum of a connection capacity of each of the plurality of virtual servers. In some embodiments, the device identifies the spillover limit as a bandwidth threshold.

In some embodiments, the pool manager allocates the number of resource uses comprising a number of exclusive uses from the exclusive quota pool and a number of non-exclusive uses from the shared quota pool. In some embodiments, the packet engine requests a resource use from the pool manager upon reaching the packet engine's allocation of resource uses. In some embodiments, the device determines that the number of resource uses available from the pool manager has been exhausted. In some embodiments, the device changes the spillover limit to a lower number of resource uses and responsive to the change, one or more of the plurality of packet engines returning a portion of the allocated number of resource uses to the pool manager. In some embodiments, the device changes the spillover limit to a higher number of resource uses and responsive to the change, one or more the plurality of packet engines requesting from the pool manager an additional the number of resource uses. In some embodiments, the device designates a first packet engine of the plurality of packet engines as spillover master for monitoring the service and changing the spillover limit based on monitoring.

The details of various embodiments of the invention are set forth in the accompanying drawings and the description below.

BRIEF DESCRIPTION OF THE FIGURES

The foregoing and other objects, aspects, features, and advantages of the invention will become more apparent and better understood by referring to the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1**A is a block diagram of an embodiment of a network environment for a client to access a server via an appliance;

FIG. **1**B is a block diagram of an embodiment of an environment for delivering a computing environment from a server to a client via an appliance;

FIG. **1**C is a block diagram of another embodiment of an environment for delivering a computing environment from a server to a client via an appliance;

FIG. **1**D is a block diagram of another embodiment of an environment for delivering a computing environment from a server to a client via an appliance;

FIGS. **1**E-**1**H are block diagrams of embodiments of a computing device;

FIG. **2**A is a block diagram of an embodiment of an appliance for processing communications between a client and a server;

FIG. **2**B is a block diagram of another embodiment of an appliance for optimizing, accelerating, load-balancing and routing communications between a client and a server;

FIG. **3** is a block diagram of an embodiment of a client for communicating with a server via the appliance;

FIG. **4**A is a block diagram of an embodiment of a virtualization environment;

FIG. **4**B is a block diagram of another embodiment of a virtualization environment;

FIG. **4**C is a block diagram of an embodiment of a virtualized appliance;

FIG. **5**A are block diagrams of embodiments of approaches to implementing parallelism in a multi-core system;

FIG. **5**B is a block diagram of an embodiment of a system utilizing a multi-core system;

FIG. **5**C is a block diagram of another embodiment of an aspect of a multi-core system;

FIG. **6** is an embodiment of an appliance for providing a technique of dynamic connection threshold management;

FIG. **7** is a flow diagram of steps of an embodiment of a method for practicing a technique of dynamic connection threshold management in conjunction with the system of FIG. **6**;

FIG. **8**A is an embodiment of an appliance for providing a technique of virtual server spillover management based on bandwidth;

FIG. **8**B is a flow diagram of steps of an embodiment of a method for practicing a technique of spillover management based on bandwidth in conjunction with the system of FIG. **8**A;

FIG. **9**A is another embodiment of an appliance for providing a technique of virtual server spillover management based on bandwidth and objects;

FIG. **9**B is a flow diagram of steps of an embodiment of a method for practicing a technique of spillover management based on bandwidth and objects in conjunction with the system of FIG. **9**A;

FIG. **10**A is an embodiment of an appliance for providing a technique of virtual server spillover management based on health;

FIG. **10**B is a flow diagram of steps of an embodiment of a method for practicing a technique of spillover management based on health in conjunction with the system of FIG. **5**A;

FIG. **11** is a block diagram of an embodiment of a multi-core system for handling limit parameters for one or more resources;

FIG. **12**A is a flow diagram depicting steps of an embodiment of a method for allocating numbers of uses of resources to a plurality of packet processing engines operating on a plurality of cores in a multi-core system;

FIG. **12**B is a flow diagram depicting steps of an embodiment of a method for borrowing from a shared quota pool and spilling over into another packet processing engine when such borrow is not possible; and

FIG. **12**C is a flow diagram depicting steps of an embodiment of a method for returning quota to a shared quota pool; and

FIG. **12**D is a flow diagram depicts steps of an embodiments of method of practicing spillover limits in a multi-core device using embodiments of pool management techniques.

The features and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings, in which like reference characters identify corresponding elements throughout. In the drawings, like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements.

DETAILED DESCRIPTION OF THE INVENTION

For purposes of reading the description of the various embodiments below, the following descriptions of the sections of the specification and their respective contents may be helpful:

- Section A describes a network environment and computing environment which may be useful for practicing embodiments described herein;
- Section B describes embodiments of systems and methods for delivering a computing environment to a remote user;
- Section C describes embodiments of systems and methods for accelerating communications between a client and a server;
- Section D describes embodiments of systems and methods for virtualizing an application delivery controller;

Section E describes embodiments of systems and methods for providing a multi-core architecture and environment;

Section E describes embodiments of systems and methods for dynamic connection spillover among virtual servers;

Section F describes embodiments of systems and methods for dynamic spillover of virtual servers based on bandwidth;

Section G describes embodiments of systems and methods for health based spillover among virtual servers; and

Section H describes embodiments of systems and methods for handling spillover in conjunction with limit parameters for multi-core systems.

A. Network and Computing Environment

Prior to discussing the specifics of embodiments of the systems and methods of an appliance and/or client, it may be helpful to discuss the network and computing environments in which such embodiments may be deployed. Referring now to FIG. **1**A, an embodiment of a network environment is depicted. In brief overview, the network environment comprises one or more clients **102***a*-**102***n* (also generally referred to as local machine(s) **102**, or client(s) **102**) in communication with one or more servers **106***a*-**106***n* (also generally referred to as server(s) **106**, or remote machine(s) **106**) via one or more networks **104**, **104'** (generally referred to as network **104**). In some embodiments, a client **102** communicates with a server **106** via an appliance **200**.

Although FIG. **1**A shows a network **104** and a network **104'** between the clients **102** and the servers **106**, the clients **102** and the servers **106** may be on the same network **104**. The networks **104** and **104'** can be the same type of network or different types of networks. The network **104** and/or the network **104'** can be a local-area network (LAN), such as a company Intranet, a metropolitan area network (MAN), or a wide area network (WAN), such as the Internet or the World Wide Web. In one embodiment, network **104'** may be a private network and network **104** may be a public network. In some embodiments, network **104** may be a private network and network **104'** a public network. In another embodiment, networks **104** and **104'** may both be private networks. In some embodiments, clients **102** may be located at a branch office of a corporate enterprise communicating via a WAN connection over the network **104** to the servers **106** located at a corporate data center.

The network **104** and/or **104'** be any type and/or form of network and may include any of the following: a point to point network, a broadcast network, a wide area network, a local area network, a telecommunications network, a data communication network, a computer network, an ATM (Asynchronous Transfer Mode) network, a SONET (Synchronous Optical Network) network, a SDH (Synchronous Digital Hierarchy) network, a wireless network and a wireline network. In some embodiments, the network **104** may comprise a wireless link, such as an infrared channel or satellite band. The topology of the network **104** and/or **104'** may be a bus, star, or ring network topology. The network **104** and/or **104'** and network topology may be of any such network or network topology as known to those ordinarily skilled in the art capable of supporting the operations described herein.

As shown in FIG. **1**A, the appliance **200**, which also may be referred to as an interface unit **200** or gateway **200**, is shown between the networks **104** and **104'**. In some embodiments, the appliance **200** may be located on network **104**. For example, a branch office of a corporate enterprise may deploy an appliance **200** at the branch office. In other embodiments, the appliance **200** may be located on network **104'**. For example, an appliance **200** may be located at a corporate data center. In yet another embodiment, a plurality of appliances **200** may be deployed on network **104**. In some embodiments, a plurality of appliances **200** may be deployed on network **104'**. In one embodiment, a first appliance **200** communicates with a second appliance **200'**. In other embodiments, the appliance **200** could be a part of any client **102** or server **106** on the same or different network **104**, **104'** as the client **102**. One or more appliances **200** may be located at any point in the network or network communications path between a client **102** and a server **106**.

In some embodiments, the appliance **200** comprises any of the network devices manufactured by Citrix Systems, Inc. of Ft. Lauderdale Fla., referred to as Citrix NetScaler devices. In other embodiments, the appliance **200** includes any of the product embodiments referred to as WebAccelerator and BigIP manufactured by F5 Networks, Inc. of Seattle, Wash. In another embodiment, the appliance **205** includes any of the DX acceleration device platforms and/or the SSL VPN series of devices, such as SA 700, SA 2000, SA 4000, and SA 6000 devices manufactured by Juniper Networks, Inc. of Sunnyvale, Calif. In yet another embodiment, the appliance **200** includes any application acceleration and/or security related appliances and/or software manufactured by Cisco Systems, Inc. of San Jose, Calif., such as the Cisco ACE Application Control Engine Module service software and network modules, and Cisco AVS Series Application Velocity System.

In one embodiment, the system may include multiple, logically-grouped servers **106**. In these embodiments, the logical group of servers may be referred to as a server farm **38**. In some of these embodiments, the serves **106** may be geographically dispersed. In some cases, a farm **38** may be administered as a single entity. In other embodiments, the server farm **38** comprises a plurality of server farms **38**. In one embodiment, the server farm executes one or more applications on behalf of one or more clients **102**.

The servers **106** within each farm **38** can be heterogeneous. One or more of the servers **106** can operate according to one type of operating system platform (e.g., WINDOWS NT, manufactured by Microsoft Corp. of Redmond, Wash.), while one or more of the other servers **106** can operate on according to another type of operating system platform (e.g., Unix or Linux). The servers **106** of each farm **38** do not need to be physically proximate to another server **106** in the same farm **38**. Thus, the group of servers **106** logically grouped as a farm **38** may be interconnected using a wide-area network (WAN) connection or medium-area network (MAN) connection. For example, a farm **38** may include servers **106** physically located in different continents or different regions of a continent, country, state, city, campus, or room. Data transmission speeds between servers **106** in the farm **38** can be increased if the servers **106** are connected using a local-area network (LAN) connection or some form of direct connection.

Servers **106** may be referred to as a file server, application server, web server, proxy server, or gateway server. In some embodiments, a server **106** may have the capacity to function as either an application server or as a master application server. In one embodiment, a server **106** may include an Active Directory. The clients **102** may also be referred to as client nodes or endpoints. In some embodiments, a client **102** has the capacity to function as both a client node seeking access to applications on a server and as an application server providing access to hosted applications for other clients **102***a*-**102***n*.

In some embodiments, a client **102** communicates with a server **106**. In one embodiment, the client **102** communicates directly with one of the servers **106** in a farm **38**. In another embodiment, the client **102** executes a program neighborhood application to communicate with a server **106** in a farm

38. In still another embodiment, the server **106** provides the functionality of a master node. In some embodiments, the client **102** communicates with the server **106** in the farm **38** through a network **104**. Over the network **104**, the client **102** can, for example, request execution of various applications hosted by the servers **106***a*-**106***n* in the farm **38** and receive output of the results of the application execution for display. In some embodiments, only the master node provides the functionality required to identify and provide address information associated with a server **106'** hosting a requested application.

In one embodiment, the server **106** provides functionality of a web server. In another embodiment, the server **106***a* receives requests from the client **102**, forwards the requests to a second server **106***b* and responds to the request by the client **102** with a response to the request from the server **106***b*. In still another embodiment, the server **106** acquires an enumeration of applications available to the client **102** and address information associated with a server **106** hosting an application identified by the enumeration of applications. In yet another embodiment, the server **106** presents the response to the request to the client **102** using a web interface. In one embodiment, the client **102** communicates directly with the server **106** to access the identified application. In another embodiment, the client **102** receives application output data, such as display data, generated by an execution of the identified application on the server **106**.

Referring now to FIG. **1**B, an embodiment of a network environment deploying multiple appliances **200** is depicted. A first appliance **200** may be deployed on a first network **104** and a second appliance **200'** on a second network **104'**. For example a corporate enterprise may deploy a first appliance **200** at a branch office and a second appliance **200'** at a data center. In another embodiment, the first appliance **200** and second appliance **200'** are deployed on the same network **104** or network **104**. For example, a first appliance **200** may be deployed for a first server farm **38**, and a second appliance **200** may be deployed for a second server farm **38'**. In another example, a first appliance **200** may be deployed at a first branch office while the second appliance **200'** is deployed at a second branch office'. In some embodiments, the first appliance **200** and second appliance **200'** work in cooperation or in conjunction with each other to accelerate network traffic or the delivery of application and data between a client and a server

Referring now to FIG. **1**C, another embodiment of a network environment deploying the appliance **200** with one or more other types of appliances, such as between one or more WAN optimization appliance **205**, **205'** is depicted. For example a first WAN optimization appliance **205** is shown between networks **104** and **104'** and s second WAN optimization appliance **205'** may be deployed between the appliance **200** and one or more servers **106**. By way of example, a corporate enterprise may deploy a first WAN optimization appliance **205** at a branch office and a second WAN optimization appliance **205'** at a data center. In some embodiments, the appliance **205** may be located on network **104'**. In other embodiments, the appliance **205'** may be located on network **104**. In some embodiments, the appliance **205'**may be located on network **104'** or network **104"**. In one embodiment, the appliance **205** and **205'** are on the same network. In another embodiment, the appliance **205** and **205'** are on different networks. In another example, a first WAN optimization appliance **205** may be deployed for a first server farm **38** and a second WAN optimization appliance **205'** for a second server farm **38'**

In one embodiment, the appliance **205** is a device for accelerating, optimizing or otherwise improving the performance, operation, or quality of service of any type and form of network traffic, such as traffic to and/or from a WAN connection. In some embodiments, the appliance **205** is a performance enhancing proxy. In other embodiments, the appliance **205** is any type and form of WAN optimization or acceleration device, sometimes also referred to as a WAN optimization controller. In one embodiment, the appliance **205** is any of the product embodiments referred to as WANScaler manufactured by Citrix Systems, Inc. of Ft. Lauderdale, Fla. In other embodiments, the appliance **205** includes any of the product embodiments referred to as BIG-IP link controller and WANjet manufactured by F5 Networks, Inc. of Seattle, Wash. In another embodiment, the appliance **205** includes any of the WX and WXC WAN acceleration device platforms manufactured by Juniper Networks, Inc. of Sunnyvale, Calif. In some embodiments, the appliance **205** includes any of the steelhead line of WAN optimization appliances manufactured by Riverbed Technology of San Francisco, Calif. In other embodiments, the appliance **205** includes any of the WAN related devices manufactured by Expand Networks Inc. of Roseland, N.J. In one embodiment, the appliance **205** includes any of the WAN related appliances manufactured by Packeteer Inc. of Cupertino, Calif., such as the PacketShaper, iShared, and SkyX product embodiments provided by Packeteer. In yet another embodiment, the appliance **205** includes any WAN related appliances and/or software manufactured by Cisco Systems, Inc. of San Jose, Calif., such as the Cisco Wide Area Network Application Services software and network modules, and Wide Area Network engine appliances.

In one embodiment, the appliance **205** provides application and data acceleration services for branch-office or remote offices. In one embodiment, the appliance **205** includes optimization of Wide Area File Services (WAFS). In another embodiment, the appliance **205** accelerates the delivery of files, such as via the Common Internet File System (CIFS) protocol. In other embodiments, the appliance **205** provides caching in memory and/or storage to accelerate delivery of applications and data. In one embodiment, the appliance **205** provides compression of network traffic at any level of the network stack or at any protocol or network layer. In another embodiment, the appliance **205** provides transport layer protocol optimizations, flow control, performance enhancements or modifications and/or management to accelerate delivery of applications and data over a WAN connection. For example, in one embodiment, the appliance **205** provides Transport Control Protocol (TCP) optimizations. In other embodiments, the appliance **205** provides optimizations, flow control, performance enhancements or modifications and/or management for any session or application layer protocol.

In another embodiment, the appliance **205** encoded any type and form of data or information into custom or standard TCP and/or IP header fields or option fields of network packet to announce presence, functionality or capability to another appliance **205'**. In another embodiment, an appliance **205'** may communicate with another appliance **205'** using data encoded in both TCP and/or IP header fields or options. For example, the appliance may use TCP option(s) or IP header fields or options to communicate one or more parameters to be used by the appliances **205**, **205'** in performing functionality, such as WAN acceleration, or for working in conjunction with each other.

In some embodiments, the appliance **200** preserves any of the information encoded in TCP and/or IP header and/or option fields communicated between appliances **205** and **205'**. For example, the appliance **200** may terminate a transport layer connection traversing the appliance **200**, such as a transport layer connection from between a client and a server traversing appliances **205** and **205'**. In one embodiment, the appliance **200** identifies and preserves any encoded information in a transport layer packet transmitted by a first appliance **205** via a first transport layer connection and communicates a transport layer packet with the encoded information to a second appliance **205'** via a second transport layer connection.

Referring now to FIG. **1**D, a network environment for delivering and/or operating a computing environment on a client **102** is depicted. In some embodiments, a server **106** includes an application delivery system **190** for delivering a computing environment or an application and/or data file to one or more clients **102**. In brief overview, a client **10** is in communication with a server **106** via network **104**, **104'** and appliance **200**. For example, the client **102** may reside in a remote office of a company, e.g., a branch office, and the server **106** may reside at a corporate data center. The client **102** comprises a client agent **120**, and a computing environment **15**. The computing environment **15** may execute or operate an application that accesses, processes or uses a data file. The computing environment **15**, application and/or data file may be delivered via the appliance **200** and/or the server **106**.

In some embodiments, the appliance **200** accelerates delivery of a computing environment **15**, or any portion thereof, to a client **102**. In one embodiment, the appliance **200** accelerates the delivery of the computing environment **15** by the application delivery system **190**. For example, the embodiments described herein may be used to accelerate delivery of a streaming application and data file processable by the application from a central corporate data center to a remote user location, such as a branch office of the company. In another embodiment, the appliance **200** accelerates transport layer traffic between a client **102** and a server **106**. The appliance **200** may provide acceleration techniques for accelerating any transport layer payload from a server **106** to a client **102**, such as: 1) transport layer connection pooling, 2) transport layer connection multiplexing, 3) transport control protocol buffering, 4) compression and 5) caching. In some embodiments, the appliance **200** provides load balancing of servers **106** in responding to requests from clients **102**. In other embodiments, the appliance **200** acts as a proxy or access server to provide access to the one or more servers **106**. In another embodiment, the appliance **200** provides a secure virtual private network connection from a first network **104** of the client **102** to the second network **104'** of the server **106**, such as an SSL VPN connection. It yet other embodiments, the appliance **200** provides application firewall security, control and management of the connection and communications between a client **102** and a server **106**.

In some embodiments, the application delivery management system **190** provides application delivery techniques to deliver a computing environment to a desktop of a user, remote or otherwise, based on a plurality of execution methods and based on any authentication and authorization policies applied via a policy engine **195**. With these techniques, a remote user may obtain a computing environment and access to server stored applications and data files from any network connected device **100**. In one embodiment, the application delivery system **190** may reside or execute on a server **106**. In another embodiment, the application delivery system **190** may reside or execute on a plurality of servers **106***a*-**106***n*. In some embodiments, the application delivery system **190** may execute in a server farm **38**. In one embodiment, the server **106** executing the application delivery system **190** may also store or provide the application and data file. In another embodiment, a first set of one or more servers **106** may execute the application delivery system **190**, and a different server **106***n* may store or provide the application and data file. In some embodiments, each of the application delivery system **190**, the application, and data file may reside or be located on different servers. In yet another embodiment, any portion of the application delivery system **190** may reside, execute or be stored on or distributed to the appliance **200**, or a plurality of appliances.

The client **102** may include a computing environment **15** for executing an application that uses or processes a data file. The client **102** via networks **104**, **104'** and appliance **200** may request an application and data file from the server **106**. In one embodiment, the appliance **200** may forward a request from the client **102** to the server **106**. For example, the client **102** may not have the application and data file stored or accessible locally. In response to the request, the application delivery system **190** and/or server **106** may deliver the application and data file to the client **102**. For example, in one embodiment, the server **106** may transmit the application as an application stream to operate in computing environment **15** on client **102**.

In some embodiments, the application delivery system **190** comprises any portion of the Citrix Access Suite™ by Citrix Systems, Inc., such as the MetaFrame or Citrix Presentation Server™ and/or any of the Microsoft® Windows Terminal Services manufactured by the Microsoft Corporation. In one embodiment, the application delivery system **190** may deliver one or more applications to clients **102** or users via a remote-display protocol or otherwise via remote-based or server-based computing. In another embodiment, the application delivery system **190** may deliver one or more applications to clients or users via steaming of the application.

In one embodiment, the application delivery system **190** includes a policy engine **195** for controlling and managing the access to, selection of application execution methods and the delivery of applications. In some embodiments, the policy engine **195** determines the one or more applications a user or client **102** may access. In another embodiment, the policy engine **195** determines how the application should be delivered to the user or client **102**, e.g., the method of execution. In some embodiments, the application delivery system **190** provides a plurality of delivery techniques from which to select a method of application execution, such as a server-based computing, streaming or delivering the application locally to the client **120** for local execution.

In one embodiment, a client **102** requests execution of an application program and the application delivery system **190** comprising a server **106** selects a method of executing the application program. In some embodiments, the server **106** receives credentials from the client **102**. In another embodiment, the server **106** receives a request for an enumeration of available applications from the client **102**. In one embodiment, in response to the request or receipt of credentials, the application delivery system **190** enumerates a plurality of application programs available to the client **102**. The application delivery system **190** receives a request to execute an enumerated application. The application delivery system **190** selects one of a predetermined number of methods for executing the enumerated application, for example, responsive to a policy of a policy engine. The application delivery system **190** may select a method of execution of the application enabling the client **102** to receive application-output data generated by execution of the application program on a server **106**. The application delivery system **190** may select a method of execution of the application enabling the local machine **10** to execute the application program locally after retrieving a plurality of application files comprising the application. In yet another embodiment, the application delivery system **190** may select a method of execution of the application to stream the application via the network **104** to the client **102**.

A client **102** may execute, operate or otherwise provide an application, which can be any type and/or form of software, program, or executable instructions such as any type and/or form of web browser, web-based client, client-server application, a thin-client computing client, an ActiveX control, or a Java applet, or any other type and/or form of executable instructions capable of executing on client **102**. In some embodiments, the application may be a server-based or a remote-based application executed on behalf of the client **102** on a server **106**. In one embodiments the server **106** may display output to the client **102** using any thin-client or remote-display protocol, such as the Independent Computing Architecture (ICA) protocol manufactured by Citrix Systems, Inc. of Ft. Lauderdale, Fla. or the Remote Desktop Protocol (RDP) manufactured by the Microsoft Corporation of Redmond, Wash. The application can use any type of protocol and it can be, for example, an HTTP client, an FTP client, an Oscar client, or a Telnet client. In other embodiments, the application comprises any type of software related to VoIP communications, such as a soft IP telephone. In further embodiments, the application comprises any application related to real-time data communications, such as applications for streaming video and/or audio.

In some embodiments, the server **106** or a server farm **38** may be running one or more applications, such as an application providing a thin-client computing or remote display presentation application. In one embodiment, the server **106** or server farm **38** executes as an application, any portion of the Citrix Access Suite™ by Citrix Systems, Inc., such as the MetaFrame or Citrix Presentation Server™, and/or any of the Microsoft® Windows Terminal Services manufactured by the Microsoft Corporation. In one embodiment, the application is an ICA client, developed by Citrix Systems, Inc. of Fort Lauderdale, Fla. In other embodiments, the application includes a Remote Desktop (RDP) client, developed by Microsoft Corporation of Redmond, Wash. Also, the server **106** may run an application, which for example, may be an application server providing email services such as Microsoft Exchange manufactured by the Microsoft Corporation of Redmond, Wash., a web or Internet server, or a desktop sharing server, or a collaboration server. In some embodiments, any of the applications may comprise any type of hosted service or products, such as GoToMeeting™ provided by Citrix Online Division, Inc. of Santa Barbara, Calif., WebEx™ provided by WebEx, Inc. of Santa Clara, Calif., or Microsoft Office Live Meeting provided by Microsoft Corporation of Redmond, Wash.

Still referring to FIG. **1**D, an embodiment of the network environment may include a monitoring server **106**A. The monitoring server **106**A may include any type and form performance monitoring service **198**. The performance monitoring service **198** may include monitoring, measurement and/or management software and/or hardware, including data collection, aggregation, analysis, management and reporting. In one embodiment, the performance monitoring service **198** includes one or more monitoring agents **197**. The monitoring agent **197** includes any software, hardware or combination thereof for performing monitoring, measurement and data collection activities on a device, such as a client **102**, server **106** or an appliance **200**, **205**. In some embodiments, the monitoring agent **197** includes any type and form of script, such as Visual Basic script, or Javascript. In one embodiment, the monitoring agent **197** executes transparently to any application and/or user of the device. In some embodiments, the monitoring agent **197** is installed and operated unobtrusively to the application or client. In yet another embodiment, the monitoring agent **197** is installed and operated without any instrumentation for the application or device.

In some embodiments, the monitoring agent **197** monitors, measures and collects data on a predetermined frequency. In other embodiments, the monitoring agent **197** monitors, measures and collects data based upon detection of any type and form of event. For example, the monitoring agent **197** may collect data upon detection of a request for a web page or receipt of an HTTP response. In another example, the monitoring agent **197** may collect data upon detection of any user input events, such as a mouse click. The monitoring agent **197** may report or provide any monitored, measured or collected data to the monitoring service **198**. In one embodiment, the monitoring agent **197** transmits information to the monitoring service **198** according to a schedule or a predetermined frequency. In another embodiment, the monitoring agent **197** transmits information to the monitoring service **198** upon detection of an event.

In some embodiments, the monitoring service **198** and/or monitoring agent **197** performs monitoring and performance measurement of any network resource or network infrastructure element, such as a client, server, server farm, appliance **200**, appliance **205**, or network connection. In one embodiment, the monitoring service **198** and/or monitoring agent **197** performs monitoring and performance measurement of any transport layer connection, such as a TCP or UDP connection. In another embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures network latency. In yet one embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures bandwidth utilization.

In other embodiments, the monitoring service **198** and/or monitoring agent **197** monitors and measures end-user response times. In some embodiments, the monitoring service **198** performs monitoring and performance measurement of an application. In another embodiment, the monitoring service **198** and/or monitoring agent **197** performs monitoring and performance measurement of any session or connection to the application. In one embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of a browser. In another embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of HTTP based transactions. In some embodiments, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of a Voice over IP (VoIP) application or session. In other embodiments, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of a remote display protocol application, such as an ICA client or RDP client. In yet another embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of any type and form of streaming media. In still a further embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of a hosted application or a Software-As-A-Service (SaaS) delivery model.

In some embodiments, the monitoring service **198** and/or monitoring agent **197** performs monitoring and performance measurement of one or more transactions, requests or responses related to application. In other embodiments, the monitoring service **198** and/or monitoring agent **197** monitors and measures any portion of an application layer stack, such as any .NET or J2EE calls. In one embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures database or SQL transactions. In yet another embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures any method, function or application programming interface (API) call.

In one embodiment, the monitoring service **198** and/or monitoring agent **197** performs monitoring and performance measurement of a delivery of application and/or data from a server to a client via one or more appliances, such as appliance **200** and/or appliance **205**. In some embodiments, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of delivery of a virtualized application. In other embodiments, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of delivery of a streaming application. In another embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of delivery of a desktop application to a client and/or the execution of the desktop application on the client. In another embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of a client/server application.

In one embodiment, the monitoring service **198** and/or monitoring agent **197** is designed and constructed to provide application performance management for the application delivery system **190**. For example, the monitoring service **198** and/or monitoring agent **197** may monitor, measure and manage the performance of the delivery of applications via the Citrix Presentation Server. In this example, the monitoring service **198** and/or monitoring agent **197** monitors individual ICA sessions. The monitoring service **198** and/or monitoring agent **197** may measure the total and per session system resource usage, as well as application and networking performance. The monitoring service **198** and/or monitoring agent **197** may identify the active servers for a given user and/or user session. In some embodiments, the monitoring service **198** and/or monitoring agent **197** monitors back-end connections between the application delivery system **190** and an application and/or database server. The monitoring service **198** and/or monitoring agent **197** may measure network latency, delay and volume per user-session or ICA session.

In some embodiments, the monitoring service **198** and/or monitoring agent **197** measures and monitors memory usage for the application delivery system **190**, such as total memory usage, per user session and/or per process. In other embodiments, the monitoring service **198** and/or monitoring agent **197** measures and monitors CPU usage the application delivery system **190**, such as total CPU usage, per user session and/or per process. In another embodiments, the monitoring service **198** and/or monitoring agent **197** measures and monitors the time required to log-in to an application, a server, or the application delivery system, such as Citrix Presentation Server. In one embodiment, the monitoring service **198** and/or monitoring agent **197** measures and monitors the duration a user is logged into an application, a server, or the application delivery system **190**. In some embodiments, the monitoring service **198** and/or monitoring agent **197** measures and monitors active and inactive session counts for an application, server or application delivery system session. In yet another embodiment, the monitoring service **198** and/or monitoring agent **197** measures and monitors user session latency.

In yet further embodiments, the monitoring service **198** and/or monitoring agent **197** measures and monitors measures and monitors any type and form of server metrics. In one embodiment, the monitoring service **198** and/or monitoring agent **197** measures and monitors metrics related to system memory, CPU usage, and disk storage. In another embodiment, the monitoring service **198** and/or monitoring agent **197** measures and monitors metrics related to page faults, such as page faults per second. In other embodiments, the monitoring service **198** and/or monitoring agent **197** measures and monitors round-trip time metrics. In yet another embodiment, the monitoring service **198** and/or monitoring agent **197** measures and monitors metrics related to application crashes, errors and/or hangs.

In some embodiments, the monitoring service **198** and monitoring agent **198** includes any of the product embodiments referred to as EdgeSight manufactured by Citrix Systems, Inc. of Ft. Lauderdale, Fla. In another embodiment, the performance monitoring service **198** and/or monitoring agent **198** includes any portion of the product embodiments referred to as the TrueView product suite manufactured by the Symphoniq Corporation of Palo Alto, Calif. In one embodiment, the performance monitoring service **198** and/or monitoring agent **198** includes any portion of the product embodiments referred to as the TeaLeaf CX product suite manufactured by the TeaLeaf Technology Inc. of San Francisco, Calif. In other embodiments, the performance monitoring service **198** and/or monitoring agent **198** includes any portion of the business service management products, such as the BMC Performance Manager and Patrol products, manufactured by BMC Software, Inc. of Houston, Tex.

The client **102**, server **106**, and appliance **200** may be deployed as and/or executed on any type and form of computing device, such as a computer, network device or appliance capable of communicating on any type and form of network and performing the operations described herein. FIGS. **1**E and **1**F depict block diagrams of a computing device **100** useful for practicing an embodiment of the client **102**, server **106** or appliance **200**. As shown in FIGS. **1**E and **1**F, each computing device **100** includes a central processing unit **101**, and a main memory unit **122**. As shown in FIG. **1**E, a computing device **100** may include a visual display device **124**, a keyboard **126** and/or a pointing device **127**, such as a mouse. Each computing device **100** may also include additional optional elements, such as one or more input/output devices **130***a*-**130***b* (generally referred to using reference numeral **130**), and a cache memory **140** in communication with the central processing unit **101**.

The central processing unit **101** is any logic circuitry that responds to and processes instructions fetched from the main memory unit **122**. In many embodiments, the central processing unit is provided by a microprocessor unit, such as: those manufactured by Intel Corporation of Mountain View, Calif.; those manufactured by Motorola Corporation of Schaumburg, Ill.; those manufactured by Transmeta Corporation of Santa Clara, Calif.; the RS/6000 processor, those manufactured by International Business Machines of White Plains, N.Y.; or those manufactured by Advanced Micro Devices of Sunnyvale, Calif. The computing device **100** may be based on any of these processors, or any other processor capable of operating as described herein.

Main memory unit **122** may be one or more memory chips capable of storing data and allowing any storage location to be directly accessed by the microprocessor **101**, such as Static random access memory (SRAM), Burst SRAM or SynchBurst SRAM (BSRAM), Dynamic random access memory (DRAM), Fast Page Mode DRAM (FPM DRAM), Enhanced DRAM (EDRAM), Extended Data Output RAM (EDO RAM), Extended Data Output DRAM (EDO DRAM), Burst Extended Data Output DRAM (BEDO DRAM), Enhanced DRAM (EDRAM), synchronous DRAM (SDRAM), JEDEC SRAM, PC 100 SDRAM, Double Data Rate SDRAM (DDR SDRAM), Enhanced SDRAM (ESDRAM), SyncLink

DRAM (SLDRAM), Direct Rambus DRAM (DRDRAM), or Ferroelectric RAM (FRAM). The main memory **122** may be based on any of the above described memory chips, or any other available memory chips capable of operating as described herein. In the embodiment shown in FIG. **1**E, the processor **101** communicates with main memory **122** via a system bus **150** (described in more detail below). FIG. **1**E depicts an embodiment of a computing device **100** in which the processor communicates directly with main memory **122** via a memory port **103**. For example, in FIG. **1**F the main memory **122** may be DRDRAM.

FIG. **1**F depicts an embodiment in which the main processor **101** communicates directly with cache memory **140** via a secondary bus, sometimes referred to as a backside bus. In other embodiments, the main processor **101** communicates with cache memory **140** using the system bus **150**. Cache memory **140** typically has a faster response time than main memory **122** and is typically provided by SRAM, BSRAM, or EDRAM. In the embodiment shown in FIG. **1**E, the processor **101** communicates with various I/O devices **130** via a local system bus **150**. Various busses may be used to connect the central processing unit **101** to any of the I/O devices **130**, including a VESA VL bus, an ISA bus, an EISA bus, a MicroChannel Architecture (MCA) bus, a PCI bus, a PCI-X bus, a PCI-Express bus, or a NuBus. For embodiments in which the I/O device is a video display **124**, the processor **101** may use an Advanced Graphics Port (AGP) to communicate with the display **124**. FIG. **1**F depicts an embodiment of a computer **100** in which the main processor **101** communicates directly with I/O device **130** via HyperTransport, Rapid I/O, or InfiniBand. FIG. **1**F also depicts an embodiment in which local busses and direct communication are mixed: the processor **101** communicates with I/O device **130** using a local interconnect bus while communicating with I/O device **130** directly.

The computing device **100** may support any suitable installation device **116**, such as a floppy disk drive for receiving floppy disks such as 3.5-inch, 5.25-inch disks or ZIP disks, a CD-ROM drive, a CD-R/RW drive, a DVD-ROM drive, tape drives of various formats, USB device, hard-drive or any other device suitable for installing software and programs such as any client agent **120**, or portion thereof. The computing device **100** may further comprise a storage device **128**, such as one or more hard disk drives or redundant arrays of independent disks, for storing an operating system and other related software, and for storing application software programs such as any program related to the client agent **120**. Optionally, any of the installation devices **116** could also be used as the storage device **128**. Additionally, the operating system and the software can be run from a bootable medium, for example, a bootable CD, such as KNOPPIX®, a bootable CD for GNU/Linux that is available as a GNU/Linux distribution from knoppix.net.

Furthermore, the computing device **100** may include a network interface **118** to interface to a Local Area Network (LAN), Wide Area Network (WAN) or the Internet through a variety of connections including, but not limited to, standard telephone lines, LAN or WAN links (e.g., 802.11, T1, T3, 56 kb, X.25), broadband connections (e.g., ISDN, Frame Relay, ATM), wireless connections, or some combination of any or all of the above. The network interface **118** may comprise a built-in network adapter, network interface card, PCMCIA network card, card bus network adapter, wireless network adapter, USB network adapter, modem or any other device suitable for interfacing the computing device **100** to any type of network capable of communication and performing the operations described herein. A wide variety of I/O devices **130***a*-**130***n* may be present in the computing device **100**. Input devices include keyboards, mice, trackpads, trackballs, microphones, and drawing tablets. Output devices include video displays, speakers, inkjet printers, laser printers, and dye-sublimation printers. The I/O devices **130** may be controlled by an I/O controller **123** as shown in FIG. **1**E. The I/O controller may control one or more I/O devices such as a keyboard **126** and a pointing device **127**, e.g., a mouse or optical pen. Furthermore, an I/O device may also provide storage **128** and/or an installation medium **116** for the computing device **100**. In still other embodiments, the computing device **100** may provide USB connections to receive handheld USB storage devices such as the USB Flash Drive line of devices manufactured by Twintech Industry, Inc. of Los Alamitos, Calif.

In some embodiments, the computing device **100** may comprise or be connected to multiple display devices **124***a*-**124***n*, which each may be of the same or different type and/or form. As such, any of the I/O devices **130***a*-**130***n* and/or the I/O controller **123** may comprise any type and/or form of suitable hardware, software, or combination of hardware and software to support, enable or provide for the connection and use of multiple display devices **124***a*-**124***n* by the computing device **100**. For example, the computing device **100** may include any type and/or form of video adapter, video card, driver, and/or library to interface, communicate, connect or otherwise use the display devices **124***a*-**124***n*. In one embodiment, a video adapter may comprise multiple connectors to interface to multiple display devices **124***a*-**124***n*. In other embodiments, the computing device **100** may include multiple video adapters, with each video adapter connected to one or more of the display devices **124***a*-**124***n*. In some embodiments, any portion of the operating system of the computing device **100** may be configured for using multiple displays **124***a*-**124***n*. In other embodiments, one or more of the display devices **124***a*-**124***n* may be provided by one or more other computing devices, such as computing devices **100***a* and **100***b* connected to the computing device **100**, for example, via a network. These embodiments may include any type of software designed and constructed to use another computer's display device as a second display device **124***a* for the computing device **100**. One ordinarily skilled in the art will recognize and appreciate the various ways and embodiments that a computing device **100** may be configured to have multiple display devices **124***a*-**124***n*.

In further embodiments, an I/O device **130** may be a bridge **170** between the system bus **150** and an external communication bus, such as a USB bus, an Apple Desktop Bus, an RS-232 serial connection, a SCSI bus, a FireWire bus, a FireWire 800 bus, an Ethernet bus, an AppleTalk bus, a Gigabit Ethernet bus, an Asynchronous Transfer Mode bus, a HIPPI bus, a Super HIPPI bus, a SerialPlus bus, a SCI/LAMP bus, a FibreChannel bus, or a Serial Attached small computer system interface bus.

A computing device **100** of the sort depicted in FIGS. **1**E and **1**F typically operate under the control of operating systems, which control scheduling of tasks and access to system resources. The computing device **100** can be running any operating system such as any of the versions of the Microsoft® Windows operating systems, the different releases of the Unix and Linux operating systems, any version of the Mac OS® for Macintosh computers, any embedded operating system, any real-time operating system, any open source operating system, any proprietary operating system, any operating systems for mobile computing devices, or any other operating system capable of running on the computing device and performing the operations described herein. Typical operating systems include: WINDOWS 3.x, WINDOWS 95, WINDOWS 98, WINDOWS 2000, WINDOWS NT 3.51, WINDOWS NT 4.0, WINDOWS CE, and WINDOWS XP, all of which are manufactured by Microsoft Corporation of Redmond, Wash.; MacOS, manufactured by Apple Computer of Cupertino, Calif.; OS/2, manufactured by International Business Machines of Armonk, N.Y.; and Linux, a freely-available operating system distributed by Caldera Corp. of Salt Lake City, Utah, or any type and/or form of a Unix operating system, among others.

In other embodiments, the computing device **100** may have different processors, operating systems, and input devices consistent with the device. For example, in one embodiment the computer **100** is a Treo 180, 270, 1060, 600 or 650 smart phone manufactured by Palm, Inc. In this embodiment, the Treo smart phone is operated under the control of the PalmOS operating system and includes a stylus input device as well as a five-way navigator device. Moreover, the computing device **100** can be any workstation, desktop computer, laptop or notebook computer, server, handheld computer, mobile telephone, any other computer, or other form of computing or telecommunications device that is capable of communication and that has sufficient processor power and memory capacity to perform the operations described herein.

As shown in FIG. **1**G, the computing device **100** may comprise multiple processors and may provide functionality for simultaneous execution of instructions or for simultaneous execution of one instruction on more than one piece of data. In some embodiments, the computing device **100** may comprise a parallel processor with one or more cores. In one of these embodiments, the computing device **100** is a shared memory parallel device, with multiple processors and/or multiple processor cores, accessing all available memory as a single global address space. In another of these embodiments, the computing device **100** is a distributed memory parallel device with multiple processors each accessing local memory only. In still another of these embodiments, the computing device **100** has both some memory which is shared and some memory which can only be accessed by particular processors or subsets of processors. In still even another of these embodiments, the computing device **100**, such as a multi-core microprocessor, combines two or more independent processors into a single package, often a single integrated circuit (IC). In yet another of these embodiments, the computing device **100** includes a chip having a CELL BROADBAND ENGINE architecture and including a Power processor element and a plurality of synergistic processing elements, the Power processor element and the plurality of synergistic processing elements linked together by an internal high speed bus, which may be referred to as an element interconnect bus.

In some embodiments, the processors provide functionality for execution of a single instruction simultaneously on multiple pieces of data (SIMD). In other embodiments, the processors provide functionality for execution of multiple instructions simultaneously on multiple pieces of data (MIMD). In still other embodiments, the processor may use any combination of SIMD and MIMD cores in a single device.

In some embodiments, the computing device **100** may comprise a graphics processing unit. In one of these embodiments, depicted in FIG. **1**H, the computing device **100** includes at least one central processing unit **101** and at least one graphics processing unit. In another of these embodiments, the computing device **100** includes at least one parallel processing unit and at least one graphics processing unit. In still another of these embodiments, the computing device **100** includes a plurality of processing units of any type, one of the plurality of processing units comprising a graphics processing unit.

In some embodiments, a first computing device **100***a* executes an application on behalf of a user of a client computing device **100***b*. In other embodiments, a computing device **100***a* executes a virtual machine, which provides an execution session within which applications execute on behalf of a user or a client computing devices **100***b*. In one of these embodiments, the execution session is a hosted desktop session. In another of these embodiments, the computing device **100** executes a terminal services session. The terminal services session may provide a hosted desktop environment. In still another of these embodiments, the execution session provides access to a computing environment, which may comprise one or more of: an application, a plurality of applications, a desktop application, and a desktop session in which one or more applications may execute.

B. Appliance Architecture

FIG. **2**A illustrates an example embodiment of the appliance **200**. The architecture of the appliance **200** in FIG. **2**A is provided by way of illustration only and is not intended to be limiting. As shown in FIG. **2**, appliance **200** comprises a hardware layer **206** and a software layer divided into a user space **202** and a kernel space **204**.

Hardware layer **206** provides the hardware elements upon which programs and services within kernel space **204** and user space **202** are executed. Hardware layer **206** also provides the structures and elements which allow programs and services within kernel space **204** and user space **202** to communicate data both internally and externally with respect to appliance **200**. As shown in FIG. **2**, the hardware layer **206** includes a processing unit **262** for executing software programs and services, a memory **264** for storing software and data, network ports **266** for transmitting and receiving data over a network, and an encryption processor **260** for performing functions related to Secure Sockets Layer processing of data transmitted and received over the network. In some embodiments, the central processing unit **262** may perform the functions of the encryption processor **260** in a single processor. Additionally, the hardware layer **206** may comprise multiple processors for each of the processing unit **262** and the encryption processor **260**. The processor **262** may include any of the processors **101** described above in connection with FIGS. **1**E and **1**F. For example, in one embodiment, the appliance **200** comprises a first processor **262** and a second processor **262'**. In other embodiments, the processor **262** or **262'** comprises a multi-core processor.

Although the hardware layer **206** of appliance **200** is generally illustrated with an encryption processor **260**, processor **260** may be a processor for performing functions related to any encryption protocol, such as the Secure Socket Layer (SSL) or Transport Layer Security (TLS) protocol. In some embodiments, the processor **260** may be a general purpose processor (GPP), and in further embodiments, may have executable instructions for performing processing of any security related protocol.

Although the hardware layer **206** of appliance **200** is illustrated with certain elements in FIG. **2**, the hardware portions or components of appliance **200** may comprise any type and form of elements, hardware or software, of a computing device, such as the computing device **100** illustrated and discussed herein in conjunction with FIGS. **1**E and **1**F. In some embodiments, the appliance **200** may comprise a server, gateway, router, switch, bridge or other type of computing or network device, and have any hardware and/or software elements associated therewith.

The operating system of appliance **200** allocates, manages, or otherwise segregates the available system memory into kernel space **204** and user space **204**. In example software architecture **200**, the operating system may be any type and/or form of Unix operating system although the invention is not so limited. As such, the appliance **200** can be running any operating system such as any of the versions of the Microsoft® Windows operating systems, the different releases of the Unix and Linux operating systems, any version of the Mac OS® for Macintosh computers, any embedded operating system, any network operating system, any real-time operating system, any open source operating system, any proprietary operating system, any operating systems for mobile computing devices or network devices, or any other operating system capable of running on the appliance **200** and performing the operations described herein.

The kernel space **204** is reserved for running the kernel **230**, including any device drivers, kernel extensions or other kernel related software. As known to those skilled in the art, the kernel **230** is the core of the operating system, and provides access, control, and management of resources and hardware-related elements of the application **104**. In accordance with an embodiment of the appliance **200**, the kernel space **204** also includes a number of network services or processes working in conjunction with a cache manager **232**, sometimes also referred to as the integrated cache, the benefits of which are described in detail further herein. Additionally, the embodiment of the kernel **230** will depend on the embodiment of the operating system installed, configured, or otherwise used by the device **200**.

In one embodiment, the device **200** comprises one network stack **267**, such as a TCP/IP based stack, for communicating with the client **102** and/or the server **106**. In one embodiment, the network stack **267** is used to communicate with a first network, such as network **108**, and a second network **110**. In some embodiments, the device **200** terminates a first transport layer connection, such as a TCP connection of a client **102**, and establishes a second transport layer connection to a server **106** for use by the client **102**, e.g., the second transport layer connection is terminated at the appliance **200** and the server **106**. The first and second transport layer connections may be established via a single network stack **267**. In other embodiments, the device **200** may comprise multiple network stacks, for example **267** and **267'**, and the first transport layer connection may be established or terminated at one network stack **267**, and the second transport layer connection on the second network stack **267'**. For example, one network stack may be for receiving and transmitting network packet on a first network, and another network stack for receiving and transmitting network packets on a second network. In one embodiment, the network stack **267** comprises a buffer **243** for queuing one or more network packets for transmission by the appliance **200**.

As shown in FIG. **2**, the kernel space **204** includes the cache manager **232**, a high-speed layer 2-7 integrated packet engine **240**, an encryption engine **234**, a policy engine **236** and multi-protocol compression logic **238**. Running these components or processes **232**, **240**, **234**, **236** and **238** in kernel space **204** or kernel mode instead of the user space **202** improves the performance of each of these components, alone and in combination. Kernel operation means that these components or processes **232**, **240**, **234**, **236** and **238** run in the core address space of the operating system of the device **200**. For example, running the encryption engine **234** in kernel mode improves encryption performance by moving encryption and decryption operations to the kernel, thereby reducing the number of transitions between the memory space or a kernel thread in kernel mode and the memory space or a thread in user mode. For example, data obtained in kernel mode may not need to be passed or copied to a process or thread running in user mode, such as from a kernel level data structure to a user level data structure. In another aspect, the number of context switches between kernel mode and user mode are also reduced. Additionally, synchronization of and communications between any of the components or processes **232**, **240**, **235**, **236** and **238** can be performed more efficiently in the kernel space **204**.

In some embodiments, any portion of the components **232**, **240**, **234**, **236** and **238** may run or operate in the kernel space **204**, while other portions of these components **232**, **240**, **234**, **236** and **238** may run or operate in user space **202**. In one embodiment, the appliance **200** uses a kernel-level data structure providing access to any portion of one or more network packets, for example, a network packet comprising a request from a client **102** or a response from a server **106**. In some embodiments, the kernel-level data structure may be obtained by the packet engine **240** via a transport layer driver interface or filter to the network stack **267**. The kernel-level data structure may comprise any interface and/or data accessible via the kernel space **204** related to the network stack **267**, network traffic or packets received or transmitted by the network stack **267**. In other embodiments, the kernel-level data structure may be used by any of the components or processes **232**, **240**, **234**, **236** and **238** to perform the desired operation of the component or process. In one embodiment, a component **232**, **240**, **234**, **236** and **238** is running in kernel mode **204** when using the kernel-level data structure, while in another embodiment, the component **232**, **240**, **234**, **236** and **238** is running in user mode when using the kernel-level data structure. In some embodiments, the kernel-level data structure may be copied or passed to a second kernel-level data structure, or any desired user-level data structure.

The cache manager **232** may comprise software, hardware or any combination of software and hardware to provide cache access, control and management of any type and form of content, such as objects or dynamically generated objects served by the originating servers **106**. The data, objects or content processed and stored by the cache manager **232** may comprise data in any format, such as a markup language, or communicated via any protocol. In some embodiments, the cache manager **232** duplicates original data stored elsewhere or data previously computed, generated or transmitted, in which the original data may require longer access time to fetch, compute or otherwise obtain relative to reading a cache memory element. Once the data is stored in the cache memory element, future use can be made by accessing the cached copy rather than refetching or recomputing the original data, thereby reducing the access time. In some embodiments, the cache memory element may comprise a data object in memory **264** of device **200**. In other embodiments, the cache memory element may comprise memory having a faster access time than memory **264**. In another embodiment, the cache memory element may comprise any type and form of storage element of the device **200**, such as a portion of a hard disk. In some embodiments, the processing unit **262** may provide cache memory for use by the cache manager **232**. In yet further embodiments, the cache manager **232** may use any portion and combination of memory, storage, or the processing unit for caching data, objects, and other content.

Furthermore, the cache manager **232** includes any logic, functions, rules, or operations to perform any embodiments of the techniques of the appliance **200** described herein. For example, the cache manager **232** includes logic or functionality to invalidate objects based on the expiration of an invalidation time period or upon receipt of an invalidation command from a client **102** or server **106**. In some embodiments, the cache manager **232** may operate as a program, service, process or task executing in the kernel space **204**, and in other embodiments, in the user space **202**. In one embodiment, a first portion of the cache manager **232** executes in the user space **202** while a second portion executes in the kernel space **204**. In some embodiments, the cache manager **232** can comprise any type of general purpose processor (GPP), or any other type of integrated circuit, such as a Field Programmable Gate Array (FPGA), Programmable Logic Device (PLD), or Application Specific Integrated Circuit (ASIC).

The policy engine **236** may include, for example, an intelligent statistical engine or other programmable application(s). In one embodiment, the policy engine **236** provides a configuration mechanism to allow a user to identify, specify, define or configure a caching policy. Policy engine **236**, in some embodiments, also has access to memory to support data structures such as lookup tables or hash tables to enable user-selected caching policy decisions. In other embodiments, the policy engine **236** may comprise any logic, rules, functions or operations to determine and provide access, control and management of objects, data or content being cached by the appliance **200** in addition to access, control and management of security, network traffic, network access, compression or any other function or operation performed by the appliance **200**. Further examples of specific caching policies are further described herein.

The encryption engine **234** comprises any logic, business rules, functions or operations for handling the processing of any security related protocol, such as SSL or TLS, or any function related thereto. For example, the encryption engine **234** encrypts and decrypts network packets, or any portion thereof, communicated via the appliance **200**. The encryption engine **234** may also setup or establish SSL or TLS connections on behalf of the client **102**_a_-**102**_n_, server **106**_a_-**106**_n_, or appliance **200**. As such, the encryption engine **234** provides offloading and acceleration of SSL processing. In one embodiment, the encryption engine **234** uses a tunneling protocol to provide a virtual private network between a client **102**_a_-**102**_n_ and a server **106**_a_-**106**_n_. In some embodiments, the encryption engine **234** is in communication with the Encryption processor **260**. In other embodiments, the encryption engine **234** comprises executable instructions running on the Encryption processor **260**.

The multi-protocol compression engine **238** comprises any logic, business rules, function or operations for compressing one or more protocols of a network packet, such as any of the protocols used by the network stack **267** of the device **200**. In one embodiment, multi-protocol compression engine **238** compresses bi-directionally between clients **102**_a_-**102**_n_ and servers **106**_a_-**106**_n_ any TCP/IP based protocol, including Messaging Application Programming Interface (MAPI) (email), File Transfer Protocol (FTP), HyperText Transfer Protocol (HTTP), Common Internet File System (CIFS) protocol (file transfer), Independent Computing Architecture (ICA) protocol, Remote Desktop Protocol (RDP), Wireless Application Protocol (WAP), Mobile IP protocol, and Voice Over IP (VoIP) protocol. In other embodiments, multi-protocol compression engine **238** provides compression of Hypertext Markup Language (HTML) based protocols and in some embodiments, provides compression of any markup languages, such as the Extensible Markup Language (XML). In one embodiment, the multi-protocol compression engine **238** provides compression of any high-performance protocol, such as any protocol designed for appliance **200** to appliance **200** communications. In another embodiment, the multi-protocol compression engine **238** compresses any payload of or any communication using a modified transport control protocol, such as Transaction TCP (T/TCP), TCP with selection acknowledgements (TCP-SACK), TCP with large windows (TCP-LW), a congestion prediction protocol such as the TCP-Vegas protocol, and a TCP spoofing protocol.

As such, the multi-protocol compression engine **238** accelerates performance for users accessing applications via desktop clients, e.g., Microsoft Outlook and non-Web thin clients, such as any client launched by popular enterprise applications like Oracle, SAP and Siebel, and even mobile clients, such as the Pocket PC. In some embodiments, the multi-protocol compression engine **238** by executing in the kernel mode **204** and integrating with packet processing engine **240** accessing the network stack **267** is able to compress any of the protocols carried by the TCP/IP protocol, such as any application layer protocol.

High speed layer 2-7 integrated packet engine **240**, also generally referred to as a packet processing engine or packet engine, is responsible for managing the kernel-level processing of packets received and transmitted by appliance **200** via network ports **266**. The high speed layer 2-7 integrated packet engine **240** may comprise a buffer for queuing one or more network packets during processing, such as for receipt of a network packet or transmission of a network packet. Additionally, the high speed layer 2-7 integrated packet engine **240** is in communication with one or more network stacks **267** to send and receive network packets via network ports **266**. The high speed layer 2-7 integrated packet engine **240** works in conjunction with encryption engine **234**, cache manager **232**, policy engine **236** and multi-protocol compression logic **238**. In particular, encryption engine **234** is configured to perform SSL processing of packets, policy engine **236** is configured to perform functions related to traffic management such as request-level content switching and request-level cache redirection, and multi-protocol compression logic **238** is configured to perform functions related to compression and decompression of data.

The high speed layer 2-7 integrated packet engine **240** includes a packet processing timer **242**. In one embodiment, the packet processing timer **242** provides one or more time intervals to trigger the processing of incoming, i.e., received, or outgoing, i.e., transmitted, network packets. In some embodiments, the high speed layer 2-7 integrated packet engine **240** processes network packets responsive to the timer **242**. The packet processing timer **242** provides any type and form of signal to the packet engine **240** to notify, trigger, or communicate a time related event, interval or occurrence. In many embodiments, the packet processing timer **242** operates in the order of milliseconds, such as for example 100 ms, 50 ms or 25 ms. For example, in some embodiments, the packet processing timer **242** provides time intervals or otherwise causes a network packet to be processed by the high speed layer 2-7 integrated packet engine **240** at a 10 ms time interval, while in other embodiments, at a 5 ms time interval, and still yet in further embodiments, as short as a 3, 2, or 1 ms time interval. The high speed layer 2-7 integrated packet engine **240** may be interfaced, integrated or in communication with the encryption engine **234**, cache manager **232**, policy engine **236** and multi-protocol compression engine **238** during operation. As such, any of the logic, functions, or operations of the encryption engine **234**, cache manager **232**, policy engine **236** and multi-protocol compression logic **238** may be performed responsive to the packet processing timer **242** and/or the packet engine **240**. Therefore, any of the logic, functions, or operations of the encryption engine **234**, cache manager **232**, policy engine **236** and multi-protocol compression logic **238** may be performed at the granularity of time intervals provided via the packet processing timer **242**, for example, at a time interval of less than or equal to 10 ms. For example, in one embodiment, the cache manager **232** may perform invalidation of any cached objects responsive to the high speed layer 2-7 integrated packet engine **240** and/or the packet processing timer **242**. In another embodiment, the expiry or invalidation time of a cached object can be set to the same order of granularity as the time interval of the packet processing timer **242**, such as at every 10 ms.

In contrast to kernel space **204**, user space **202** is the memory area or portion of the operating system used by user mode applications or programs otherwise running in user mode. A user mode application may not access kernel space **204** directly and uses service calls in order to access kernel services. As shown in FIG. **2**, user space **202** of appliance **200** includes a graphical user interface (GUI) **210**, a command line interface (CLI) **212**, shell services **214**, health monitoring program **216**, and daemon services **218**. GUI **210** and CLI **212** provide a means by which a system administrator or other user can interact with and control the operation of appliance **200**, such as via the operating system of the appliance **200**. The GUI **210** or CLI **212** can comprise code running in user space **202** or kernel space **204**. The GUI **210** may be any type and form of graphical user interface and may be presented via text, graphical or otherwise, by any type of program or application, such as a browser. The CLI **212** may be any type and form of command line or text-based interface, such as a command line provided by the operating system. For example, the CLI **212** may comprise a shell, which is a tool to enable users to interact with the operating system. In some embodiments, the CLI **212** may be provided via a bash, csh, tcsh, or ksh type shell. The shell services **214** comprises the programs, services, tasks, processes or executable instructions to support interaction with the appliance **200** or operating system by a user via the GUI **210** and/or CLI **212**.

Health monitoring program **216** is used to monitor, check, report and ensure that network systems are functioning properly and that users are receiving requested content over a network. Health monitoring program **216** comprises one or more programs, services, tasks, processes or executable instructions to provide logic, rules, functions or operations for monitoring any activity of the appliance **200**. In some embodiments, the health monitoring program **216** intercepts and inspects any network traffic passed via the appliance **200**. In other embodiments, the health monitoring program **216** interfaces by any suitable means and/or mechanisms with one or more of the following: the encryption engine **234**, cache manager **232**, policy engine **236**, multi-protocol compression logic **238**, packet engine **240**, daemon services **218**, and shell services **214**. As such, the health monitoring program **216** may call any application programming interface (API) to determine a state, status, or health of any portion of the appliance **200**. For example, the health monitoring program **216** may ping or send a status inquiry on a periodic basis to check if a program, process, service or task is active and currently running. In another example, the health monitoring program **216** may check any status, error or history logs provided by any program, process, service or task to determine any condition, status or error with any portion of the appliance **200**.

Daemon services **218** are programs that run continuously or in the background and handle periodic service requests received by appliance **200**. In some embodiments, a daemon service may forward the requests to other programs or processes, such as another daemon service **218** as appropriate. As known to those skilled in the art, a daemon service **218** may run unattended to perform continuous or periodic system wide functions, such as network control, or to perform any desired task. In some embodiments, one or more daemon services **218** run in the user space **202**, while in other embodiments, one or more daemon services **218** run in the kernel space.

Referring now to FIG. 2B, another embodiment of the appliance **200** is depicted. In brief overview, the appliance **200** provides one or more of the following services, functionality or operations: SSL VPN connectivity **280**, switching/load balancing **284**, Domain Name Service resolution **286**, acceleration **288** and an application firewall **290** for communications between one or more clients **102** and one or more servers **106**. Each of the servers **106** may provide one or more network related services **270*a*-270*n*** (referred to as services **270**). For example, a server **106** may provide an http service **270**. The appliance **200** comprises one or more virtual servers or virtual internet protocol servers, referred to as a vServer, VIP server, or just VIP **275*a*-275*n*** (also referred herein as vServer **275**). The vServer **275** receives, intercepts or otherwise processes communications between a client **102** and a server **106** in accordance with the configuration and operations of the appliance **200**.

The vServer **275** may comprise software, hardware or any combination of software and hardware. The vServer **275** may comprise any type and form of program, service, task, process or executable instructions operating in user mode **202**, kernel mode **204** or any combination thereof in the appliance **200**. The vServer **275** includes any logic, functions, rules, or operations to perform any embodiments of the techniques described herein, such as SSL VPN **280**, switching/load balancing **284**, Domain Name Service resolution **286**, acceleration **288** and an application firewall **290**. In some embodiments, the vServer **275** establishes a connection to a service **270** of a server **106**. The service **275** may comprise any program, application, process, task or set of executable instructions capable of connecting to and communicating to the appliance **200**, client **102** or vServer **275**. For example, the service **275** may comprise a web server, http server, ftp, email or database server. In some embodiments, the service **270** is a daemon process or network driver for listening, receiving and/or sending communications for an application, such as email, database or an enterprise application. In some embodiments, the service **270** may communicate on a specific IP address, or IP address and port.

In some embodiments, the vServer **275** applies one or more policies of the policy engine **236** to network communications between the client **102** and server **106**. In one embodiment, the policies are associated with a VServer **275**. In another embodiment, the policies are based on a user, or a group of users. In yet another embodiment, a policy is global and applies to one or more vServers **275*a*-275*n***, and any user or group of users communicating via the appliance **200**. In some embodiments, the policies of the policy engine have conditions upon which the policy is applied based on any content of the communication, such as internet protocol address, port, protocol type, header or fields in a packet, or the context of the communication, such as user, group of the user, vServer **275**, transport layer connection, and/or identification or attributes of the client **102** or server **106**.

In other embodiments, the appliance **200** communicates or interfaces with the policy engine **236** to determine authentication and/or authorization of a remote user or a remote client **102** to access the computing environment **15**, application, and/or data file from a server **106**. In another embodiment, the appliance **200** communicates or interfaces with the policy engine **236** to determine authentication and/or authorization of a remote user or a remote client **102** to have the application delivery system **190** deliver one or more of the computing environment **15**, application, and/or data file. In yet another embodiment, the appliance **200** establishes a VPN or SSL VPN connection based on the policy engine's **236** authentication and/or authorization of a remote user or a remote client **102** In one embodiment, the appliance **200** controls the flow of network traffic and communication sessions based on policies of the policy engine **236**. For example, the appliance **200** may control the access to a computing environment **15**, application or data file based on the policy engine **236**.

In some embodiments, the vServer **275** establishes a transport layer connection, such as a TCP or UDP connection with a client **102** via the client agent **120**. In one embodiment, the vServer **275** listens for and receives communications from the client **102**. In other embodiments, the vServer **275** establishes a transport layer connection, such as a TCP or UDP connection with a client server **106**. In one embodiment, the vServer **275** establishes the transport layer connection to an internet protocol address and port of a server **270** running on the server **106**. In another embodiment, the vServer **275** associates a first transport layer connection to a client **102** with a second transport layer connection to the server **106**. In some embodiments, a vServer **275** establishes a pool of transport layer connections to a server **106** and multiplexes client requests via the pooled transport layer connections.

In some embodiments, the appliance **200** provides a SSL VPN connection **280** between a client **102** and a server **106**. For example, a client **102** on a first network **102** requests to establish a connection to a server **106** on a second network **104'**. In some embodiments, the second network **104'** is not routable from the first network **104**. In other embodiments, the client **102** is on a public network **104** and the server **106** is on a private network **104'**, such as a corporate network. In one embodiment, the client agent **120** intercepts communications of the client **102** on the first network **104**, encrypts the communications, and transmits the communications via a first transport layer connection to the appliance **200**. The appliance **200** associates the first transport layer connection on the first network **104** to a second transport layer connection to the server **106** on the second network **104**. The appliance **200** receives the intercepted communication from the client agent **102**, decrypts the communications, and transmits the communication to the server **106** on the second network **104** via the second transport layer connection. The second transport layer connection may be a pooled transport layer connection. As such, the appliance **200** provides an end-to-end secure transport layer connection for the client **102** between the two networks **104**, **104'**.

In one embodiment, the appliance **200** hosts an intranet internet protocol or intranetIP **282** address of the client **102** on the virtual private network **104**. The client **102** has a local network identifier, such as an internet protocol (IP) address and/or host name on the first network **104**. When connected to the second network **104'** via the appliance **200**, the appliance **200** establishes, assigns or otherwise provides an IntranetIP, which is network identifier, such as IP address and/or host name, for the client **102** on the second network **104'**. The appliance **200** listens for and receives on the second or private network **104'** for any communications directed towards the client **102** using the client's established IntranetIP **282**. In one embodiment, the appliance **200** acts as or on behalf of the client **102** on the second private network **104**. For example, in another embodiment, a vServer **275** listens for and responds to communications to the IntranetIP **282** of the client **102**. In some embodiments, if a computing device **100** on the second network **104'** transmits a request, the appliance **200** processes the request as if it were the client **102**. For example, the appliance **200** may respond to a ping to the client's IntranetIP **282**. In another example, the appliance may establish a connection, such as a TCP or UDP connection, with computing device **100** on the second network **104** requesting a connection with the client's IntranetIP **282**.

In some embodiments, the appliance **200** provides one or more of the following acceleration techniques **288** to communications between the client **102** and server **106**: 1) compression; 2) decompression; 3) Transmission Control Protocol pooling; 4) Transmission Control Protocol multiplexing; 5) Transmission Control Protocol buffering; and 6) caching. In one embodiment, the appliance **200** relieves servers **106** of much of the processing load caused by repeatedly opening and closing transport layers connections to clients **102** by opening one or more transport layer connections with each server **106** and maintaining these connections to allow repeated data accesses by clients via the Internet. This technique is referred to herein as "connection pooling".

In some embodiments, in order to seamlessly splice communications from a client **102** to a server **106** via a pooled transport layer connection, the appliance **200** translates or multiplexes communications by modifying sequence number and acknowledgment numbers at the transport layer protocol level. This is referred to as "connection multiplexing". In some embodiments, no application layer protocol interaction is required. For example, in the case of an in-bound packet (that is, a packet received from a client **102**), the source network address of the packet is changed to that of an output port of appliance **200**, and the destination network address is changed to that of the intended server. In the case of an outbound packet (that is, one received from a server **106**), the source network address is changed from that of the server **106** to that of an output port of appliance **200** and the destination address is changed from that of appliance **200** to that of the requesting client **102**. The sequence numbers and acknowledgment numbers of the packet are also translated to sequence numbers and acknowledgement expected by the client **102** on the appliance's **200** transport layer connection to the client **102**. In some embodiments, the packet checksum of the transport layer protocol is recalculated to account for these translations.

In another embodiment, the appliance **200** provides switching or load-balancing functionality **284** for communications between the client **102** and server **106**. In some embodiments, the appliance **200** distributes traffic and directs client requests to a server **106** based on layer 4 or application-layer request data. In one embodiment, although the network layer or layer 2 of the network packet identifies a destination server **106**, the appliance **200** determines the server **106** to distribute the network packet by application information and data carried as payload of the transport layer packet. In one embodiment, the health monitoring programs **216** of the appliance **200** monitor the health of servers to determine the server **106** for which to distribute a client's request. In some embodiments, if the appliance **200** detects a server **106** is not available or has a load over a predetermined threshold, the appliance **200** can direct or distribute client requests to another server **106**.

In some embodiments, the appliance **200** acts as a Domain Name Service (DNS) resolver or otherwise provides resolution of a DNS request from clients **102**. In some embodiments, the appliance intercepts' a DNS request transmitted by the client **102**. In one embodiment, the appliance **200** responds to a client's DNS request with an IP address of or hosted by the appliance **200**. In this embodiment, the client **102** transmits network communication for the domain name to the appliance **200**. In another embodiment, the appliance **200** responds to a client's DNS request with an IP address of or hosted by a second appliance **200'**. In some embodiments, the appliance **200** responds to a client's DNS request with an IP address of a server **106** determined by the appliance **200**.

In yet another embodiment, the appliance **200** provides application firewall functionality **290** for communications between the client **102** and server **106**. In one embodiment, the policy engine **236** provides rules for detecting and blocking illegitimate requests. In some embodiments, the application firewall **290** protects against denial of service (DoS) attacks. In other embodiments, the appliance inspects the content of intercepted requests to identify and block application-based attacks. In some embodiments, the rules/policy engine **236** comprises one or more application firewall or security control policies for providing protections against various classes and types of web or Internet based vulnerabilities, such as one or more of the following: 1) buffer overflow, 2) CGI-BIN parameter manipulation, 3) form/hidden field manipulation, 4) forceful browsing, 5) cookie or session poisoning, 6) broken access control list (ACLs) or weak passwords, 7) cross-site scripting (XSS), 8) command injection, 9) SQL injection, 10) error triggering sensitive information leak, 11) insecure use of cryptography, 12) server misconfiguration, 13) back doors and debug options, 14) website defacement, 15) platform or operating systems vulnerabilities, and 16) zero-day exploits. In an embodiment, the application firewall **290** provides HTML form field protection in the form of inspecting or analyzing the network communication for one or more of the following: 1) required fields are returned, 2) no added field allowed, 3) read-only and hidden field enforcement, 4) drop-down list and radio button field conformance, and 5) form-field max-length enforcement. In some embodiments, the application firewall **290** ensures cookies are not modified. In other embodiments, the application firewall **290** protects against forceful browsing by enforcing legal URLs.

In still yet other embodiments, the application firewall **290** protects any confidential information contained in the network communication. The application firewall **290** may inspect or analyze any network communication in accordance with the rules or polices of the engine **236** to identify any confidential information in any field of the network packet. In some embodiments, the application firewall **290** identifies in the network communication one or more occurrences of a credit card number, password, social security number, name, patient code, contact information, and age. The encoded portion of the network communication may comprise these occurrences or the confidential information. Based on these occurrences, in one embodiment, the application firewall **290** may take a policy action on the network communication, such as prevent transmission of the network communication. In another embodiment, the application firewall **290** may rewrite, remove or otherwise mask such identified occurrence or confidential information.

Still referring to FIG. **2**B, the appliance **200** may include a performance monitoring agent **197** as discussed above in conjunction with FIG. **1**D. In one embodiment, the appliance **200** receives the monitoring agent **197** from the monitoring service **198** or monitoring server **106** as depicted in FIG. **1**D. In some embodiments, the appliance **200** stores the monitoring agent **197** in storage, such as disk, for delivery to any client or server in communication with the appliance **200**. For example, in one embodiment, the appliance **200** transmits the monitoring agent **197** to a client upon receiving a request to establish a transport layer connection. In other embodiments, the appliance **200** transmits the monitoring agent **197** upon establishing the transport layer connection with the client **102**. In another embodiment, the appliance **200** transmits the monitoring agent **197** to the client upon intercepting or detecting a request for a web page. In yet another embodiment, the appliance **200** transmits the monitoring agent **197** to a client or a server in response to a request from the monitoring server **198**. In one embodiment, the appliance **200** transmits the monitoring agent **197** to a second appliance **200'** or appliance **205**.

In other embodiments, the appliance **200** executes the monitoring agent **197**. In one embodiment, the monitoring agent **197** measures and monitors the performance of any application, program, process, service, task or thread executing on the appliance **200**. For example, the monitoring agent **197** may monitor and measure performance and operation of vServers **275**A-**275**N. In another embodiment, the monitoring agent **197** measures and monitors the performance of any transport layer connections of the appliance **200**. In some embodiments, the monitoring agent **197** measures and monitors the performance of any user sessions traversing the appliance **200**. In one embodiment, the monitoring agent **197** measures and monitors the performance of any virtual private network connections and/or sessions traversing the appliance **200**, such an SSL VPN session. In still further embodiments, the monitoring agent **197** measures and monitors the memory, CPU and disk usage and performance of the appliance **200**. In yet another embodiment, the monitoring agent **197** measures and monitors the performance of any acceleration technique **288** performed by the appliance **200**, such as SSL offloading, connection pooling and multiplexing, caching, and compression. In some embodiments, the monitoring agent **197** measures and monitors the performance of any load balancing and/or content switching **284** performed by the appliance **200**. In other embodiments, the monitoring agent **197** measures and monitors the performance of application firewall **290** protection and processing performed by the appliance **200**.

C. Client Agent

Referring now to FIG. **3**, an embodiment of the client agent **120** is depicted. The client **102** includes a client agent **120** for establishing and exchanging communications with the appliance **200** and/or server **106** via a network **104**. In brief overview, the client **102** operates on computing device **100** having an operating system with a kernel mode **302** and a user mode **303**, and a network stack **310** with one or more layers **310***a*-**310***b*. The client **102** may have installed and/or execute one or more applications. In some embodiments, one or more applications may communicate via the network stack **310** to a network **104**. One of the applications, such as a web browser, may also include a first program **322**. For example, the first program **322** may be used in some embodiments to install and/or execute the client agent **120**, or any portion thereof. The client agent **120** includes an interception mechanism, or interceptor **350**, for intercepting network communications from the network stack **310** from the one or more applications.

The network stack **310** of the client **102** may comprise any type and form of software, or hardware, or any combinations thereof, for providing connectivity to and communications with a network. In one embodiment, the network stack **310** comprises a software implementation for a network protocol suite. The network stack **310** may comprise one or more network layers, such as any networks layers of the Open Systems Interconnection (OSI) communications model as those skilled in the art recognize and appreciate. As such, the network stack **310** may comprise any type and form of protocols for any of the following layers of the OSI model: 1) physical link layer, 2) data link layer, 3) network layer, 4) transport layer, 5) session layer, 6) presentation layer, and 7) application layer. In one embodiment, the network stack **310** may comprise a transport control protocol (TCP) over the network layer protocol of the internet protocol (IP), generally referred to as TCP/IP. In some embodiments, the TCP/IP protocol may be carried over the Ethernet protocol, which may comprise any of the family of IEEE wide-area-network (WAN) or local-area-network (LAN) protocols, such as those protocols covered by the IEEE 802.3. In some embodiments, the network stack **310** comprises any type and form of a wireless protocol, such as IEEE 802.11 and/or mobile internet protocol.

In view of a TCP/IP based network, any TCP/IP based protocol may be used, including Messaging Application Programming Interface (MAPI) (email), File Transfer Protocol (FTP), HyperText Transfer Protocol (HTTP), Common Internet File System (CIFS) protocol (file transfer), Independent Computing Architecture (ICA) protocol, Remote Desktop Protocol (RDP), Wireless Application Protocol (WAP), Mobile IP protocol, and Voice Over IP (VoIP) protocol. In another embodiment, the network stack **310** comprises any type and form of transport control protocol, such as a modified transport control protocol, for example a Transaction TCP (T/TCP), TCP with selection acknowledgements (TCP-SACK), TCP with large windows (TCP-LW), a congestion prediction protocol such as the TCP-Vegas protocol, and a TCP spoofing protocol. In other embodiments, any type and form of user datagram protocol (UDP), such as UDP over IP, may be used by the network stack **310**, such as for voice communications or real-time data communications.

Furthermore, the network stack **310** may include one or more network drivers supporting the one or more layers, such as a TCP driver or a network layer driver. The network drivers may be included as part of the operating system of the computing device **100** or as part of any network interface cards or other network access components of the computing device **100**. In some embodiments, any of the network drivers of the network stack **310** may be customized, modified or adapted to provide a custom or modified portion of the network stack **310** in support of any of the techniques described herein. In other embodiments, the acceleration program **120** is designed and constructed to operate with or work in conjunction with the network stack **310** installed or otherwise provided by the operating system of the client **102**.

The network stack **310** comprises any type and form of interfaces for receiving, obtaining, providing or otherwise accessing any information and data related to network communications of the client **102**. In one embodiment, an interface to the network stack **310** comprises an application programming interface (API). The interface may also comprise any function call, hooking or filtering mechanism, event or call back mechanism, or any type of interfacing technique. The network stack **310** via the interface may receive or provide any type and form of data structure, such as an object, related to functionality or operation of the network stack **310**. For example, the data structure may comprise information and data related to a network packet or one or more network packets. In some embodiments, the data structure comprises a portion of the network packet processed at a protocol layer of the network stack **310**, such as a network packet of the transport layer. In some embodiments, the data structure **325** comprises a kernel-level data structure, while in other embodiments, the data structure **325** comprises a user-mode data structure. A kernel-level data structure may comprise a data structure obtained or related to a portion of the network stack **310** operating in kernel-mode **302**, or a network driver or other software running in kernel-mode **302**, or any data structure obtained or received by a service, process, task, thread or other executable instructions running or operating in kernel-mode of the operating system.

Additionally, some portions of the network stack **310** may execute or operate in kernel-mode **302**, for example, the data link or network layer, while other portions execute or operate in user-mode **303**, such as an application layer of the network stack **310**. For example, a first portion **310***a* of the network stack may provide user-mode access to the network stack **310** to an application while a second portion **310***a* of the network stack **310** provides access to a network. In some embodiments, a first portion **310***a* of the network stack may comprise one or more upper layers of the network stack **310**, such as any of layers **5**-**7**. In other embodiments, a second portion **310***b* of the network stack **310** comprises one or more lower layers, such as any of layers **1**-**4**. Each of the first portion **310***a* and second portion **310***b* of the network stack **310** may comprise any portion of the network stack **310**, at any one or more network layers, in user-mode **203**, kernel-mode, **202**, or combinations thereof, or at any portion of a network layer or interface point to a network layer or any portion of or interface point to the user-mode **203** and kernel-mode **203**.

The interceptor **350** may comprise software, hardware, or any combination of software and hardware. In one embodiment, the interceptor **350** intercept a network communication at any point in the network stack **310**, and redirects or transmits the network communication to a destination desired, managed or controlled by the interceptor **350** or client agent **120**. For example, the interceptor **350** may intercept a network communication of a network stack **310** of a first network and transmit the network communication to the appliance **200** for transmission on a second network **104**. In some embodiments, the interceptor **350** comprises any type interceptor **350** comprises a driver, such as a network driver constructed and designed to interface and work with the network stack **310**. In some embodiments, the client agent **120** and/or interceptor **350** operates at one or more layers of the network stack **310**, such as at the transport layer. In one embodiment, the interceptor **350** comprises a filter driver, hooking mechanism, or any form and type of suitable network driver interface that interfaces to the transport layer of the network stack, such as via the transport driver interface (TDI). In some embodiments, the interceptor **350** interfaces to a first protocol layer, such as the transport layer and another protocol layer, such as any layer above the transport protocol layer, for example, an application protocol layer. In one embodiment, the interceptor **350** may comprise a driver complying with the Network Driver Interface Specification (NDIS), or a NDIS driver. In another embodiment, the interceptor **350** may comprise a min-filter or a mini-port driver. In one embodiment, the interceptor **350**, or portion thereof, operates in kernel-mode **202**. In another embodiment, the interceptor **350**, or portion thereof, operates in user-mode **203**. In some embodiments, a portion of the interceptor **350** operates in kernel-mode **202** while another portion of the interceptor **350** operates in user-mode **203**. In other embodiments, the client agent **120** operates in user-mode **203** but interfaces via the interceptor **350** to a kernel-mode driver, process, service, task or portion of the operating system, such as to obtain a kernel-level data structure **225**. In further embodiments, the interceptor **350** is a user-mode application or program, such as application.

In one embodiment, the interceptor **350** intercepts any transport layer connection requests. In these embodiments, the interceptor **350** execute transport layer application programming interface (API) calls to set the destination information, such as destination IP address and/or port to a desired location for the location. In this manner, the interceptor **350** intercepts and redirects the transport layer connection to a IP address and port controlled or managed by the interceptor **350** or client agent **120**. In one embodiment, the interceptor **350** sets the destination information for the connection to a local IP address and port of the client **102** on which the client agent **120** is listening. For example, the client agent **120** may comprise a proxy service listening on a local IP address and port for redirected transport layer communications. In some embodiments, the client agent **120** then communicates the redirected transport layer communication to the appliance **200**.

In some embodiments, the interceptor **350** intercepts a Domain Name Service (DNS) request. In one embodiment, the client agent **120** and/or interceptor **350** resolves the DNS request. In another embodiment, the interceptor transmits the intercepted DNS request to the appliance **200** for DNS resolution. In one embodiment, the appliance **200** resolves the DNS request and communicates the DNS response to the client agent **120**. In some embodiments, the appliance **200** resolves the DNS request via another appliance **200'** or a DNS server **106**.

In yet another embodiment, the client agent **120** may comprise two agents **120** and **120'**. In one embodiment, a first agent **120** may comprise an interceptor **350** operating at the network layer of the network stack **310**. In some embodiments, the first agent **120** intercepts network layer requests such as Internet Control Message Protocol (ICMP) requests (e.g., ping and traceroute). In other embodiments, the second agent **120'** may operate at the transport layer and intercept transport layer communications. In some embodiments, the first agent **120** intercepts communications at one layer of the network stack **210** and interfaces with or communicates the intercepted communication to the second agent **120'**.

The client agent **120** and/or interceptor **350** may operate at or interface with a protocol layer in a manner transparent to any other protocol layer of the network stack **310**. For example, in one embodiment, the interceptor **350** operates or interfaces with the transport layer of the network stack **310** transparently to any protocol layer below the transport layer, such as the network layer, and any protocol layer above the transport layer, such as the session, presentation or application layer protocols. This allows the other protocol layers of the network stack **310** to operate as desired and without modification for using the interceptor **350**. As such, the client agent **120** and/or interceptor **350** can interface with the transport layer to secure, optimize, accelerate, route or load-balance any communications provided via any protocol carried by the transport layer, such as any application layer protocol over TCP/IP.

Furthermore, the client agent **120** and/or interceptor may operate at or interface with the network stack **310** in a manner transparent to any application, a user of the client **102**, and any other computing device, such as a server, in communications with the client **102**. The client agent **120** and/or interceptor **350** may be installed and/or executed on the client **102** in a manner without modification of an application. In some embodiments, the user of the client **102** or a computing device in communications with the client **102** are not aware of the existence, execution or operation of the client agent **120** and/or interceptor **350**. As such, in some embodiments, the client agent **120** and/or interceptor **350** is installed, executed, and/or operated transparently to an application, user of the client **102**, another computing device, such as a server, or any of the protocol layers above and/or below the protocol layer interfaced to by the interceptor **350**.

The client agent **120** includes an acceleration program **302**, a streaming client **306**, a collection agent **304**, and/or monitoring agent **197**. In one embodiment, the client agent **120** comprises an Independent Computing Architecture (ICA) client, or any portion thereof, developed by Citrix Systems, Inc. of Fort Lauderdale, Fla., and is also referred to as an ICA client. In some embodiments, the client **120** comprises an application streaming client **306** for streaming an application from a server **106** to a client **102**. In some embodiments, the client agent **120** comprises an acceleration program **302** for accelerating communications between client **102** and server **106**. In another embodiment, the client agent **120** includes a collection agent **304** for performing end-point detection/scanning and collecting end-point information for the appliance **200** and/or server **106**.

In some embodiments, the acceleration program **302** comprises a client-side acceleration program for performing one or more acceleration techniques to accelerate, enhance or otherwise improve a client's communications with and/or access to a server **106**, such as accessing an application provided by a server **106**. The logic, functions, and/or operations of the executable instructions of the acceleration program **302** may perform one or more of the following acceleration techniques: 1) multi-protocol compression, 2) transport control protocol pooling, 3) transport control protocol multiplexing, 4) transport control protocol buffering, and 5) caching via a cache manager. Additionally, the acceleration program **302** may perform encryption and/or decryption of any communications received and/or transmitted by the client **102**. In some embodiments, the acceleration program **302** performs one or more of the acceleration techniques in an integrated manner or fashion. Additionally, the acceleration program **302** can perform compression on any of the protocols, or multiple-protocols, carried as a payload of a network packet of the transport layer protocol.

The streaming client **306** comprises an application, program, process, service, task or executable instructions for receiving and executing a streamed application from a server **106**. A server **106** may stream one or more application data files to the streaming client **306** for playing, executing or otherwise causing to be executed the application on the client **102**. In some embodiments, the server **106** transmits a set of compressed or packaged application data files to the streaming client **306**. In some embodiments, the plurality of application files are compressed and stored on a file server within an archive file such as a CAB, ZIP, SIT, TAR, JAR or other archive. In one embodiment, the server **106** decompresses, unpackages or unarchives the application files and transmits the files to the client **102**. In another embodiment, the client **102** decompresses, unpackages or unarchives the application files. The streaming client **306** dynamically installs the application, or portion thereof, and executes the application. In one embodiment, the streaming client **306** may be an executable program. In some embodiments, the streaming client **306** may be able to launch another executable program.

The collection agent **304** comprises an application, program, process, service, task or executable instructions for identifying, obtaining and/or collecting information about the client **102**. In some embodiments, the appliance **200** transmits the collection agent **304** to the client **102** or client agent **120**. The collection agent **304** may be configured according to one or more policies of the policy engine **236** of the appliance. In other embodiments, the collection agent **304** transmits collected information on the client **102** to the appliance **200**. In one embodiment, the policy engine **236** of the appliance **200** uses the collected information to determine and provide access, authentication and authorization control of the client's connection to a network **104**.

In one embodiment, the collection agent **304** comprises an end-point detection and scanning mechanism, which identifies and determines one or more attributes or characteristics of the client. For example, the collection agent **304** may identify and determine any one or more of the following client-side attributes: 1) the operating system an/or a version of an operating system, 2) a service pack of the operating system, 3) a running service, 4) a running process, and 5) a file. The collection agent **304** may also identify and determine the presence or versions of any one or more of the following on the client: 1) antivirus software, 2) personal firewall software, 3) anti-spam software, and 4) internet security software. The policy engine **236** may have one or more policies based on any one or more of the attributes or characteristics of the client or client-side attributes.

In some embodiments, the client agent **120** includes a monitoring agent **197** as discussed in conjunction with FIGS. **1**D and **2**B. The monitoring agent **197** may be any type and form of script, such as Visual Basic or Java script. In one embodiment, the monitoring agent **129** monitors and measures performance of any portion of the client agent **120**. For example, in some embodiments, the monitoring agent **129** monitors and measures performance of the acceleration program **302**. In another embodiment, the monitoring agent **129** monitors and measures performance of the streaming client **306**. In other embodiments, the monitoring agent **129** monitors and measures performance of the collection agent **304**. In still another embodiment, the monitoring agent **129** monitors and measures performance of the interceptor **350**. In some embodiments, the monitoring agent **129** monitors and measures any resource of the client **102**, such as memory, CPU and disk.

The monitoring agent **197** may monitor and measure performance of any application of the client. In one embodiment, the monitoring agent **129** monitors and measures performance of a browser on the client **102**. In some embodiments, the monitoring agent **197** monitors and measures performance of any application delivered via the client agent **120**. In other embodiments, the monitoring agent **197** measures and monitors end user response times for an application, such as web-based or HTTP response times. The monitoring agent **197** may monitor and measure performance of an ICA or RDP client. In another embodiment, the monitoring agent **197** measures and monitors metrics for a user session or application session. In some embodiments, monitoring agent **197** measures and monitors an ICA or RDP session. In one embodiment, the monitoring agent **197** measures and monitors the performance of the appliance **200** in accelerating delivery of an application and/or data to the client **102**.

In some embodiments and still referring to FIG. **3**, a first program **322** may be used to install and/or execute the client agent **120**, or portion thereof, such as the interceptor **350**, automatically, silently, transparently, or otherwise. In one embodiment, the first program **322** comprises a plugin component, such an ActiveX control or Java control or script that is loaded into and executed by an application. For example, the first program comprises an ActiveX control loaded and run by a web browser application, such as in the memory space or context of the application. In another embodiment, the first program **322** comprises a set of executable instructions loaded into and run by the application, such as a browser. In one embodiment, the first program **322** comprises a designed and constructed program to install the client agent **120**. In some embodiments, the first program **322** obtains, downloads, or receives the client agent **120** via the network from another computing device. In another embodiment, the first program **322** is an installer program or a plug and play manager for installing programs, such as network drivers, on the operating system of the client **102**.

D. Systems and Methods for Providing Virtualized Application Delivery Controller

Referring now to FIG. **4**A, a block diagram depicts one embodiment of a virtualization environment **400**. In brief overview, a computing device **100** includes a hypervisor layer, a virtualization layer, and a hardware layer. The hypervisor layer includes a hypervisor **401** (also referred to as a virtualization manager) that allocates and manages access to a number of physical resources in the hardware layer (e.g., the processor(s) **421**, and disk(s) **428**) by at least one virtual machine executing in the virtualization layer. The virtualization layer includes at least one operating system **410** and a plurality of virtual resources allocated to the at least one operating system **410**. Virtual resources may include, without limitation, a plurality of virtual processors **432***a*, **432***b*, **432***c* (generally **432**), and virtual disks **442***a*, **442***b*, **442***c* (generally **442**), as well as virtual resources such as virtual memory and virtual network interfaces. The plurality of virtual resources and the operating system **410** may be referred to as a virtual machine **406**. A virtual machine **406** may include a control operating system **405** in communication with the hypervisor **401** and used to execute applications for managing and configuring other virtual machines on the computing device **100**.

In greater detail, a hypervisor **401** may provide virtual resources to an operating system in any manner which simulates the operating system having access to a physical device. A hypervisor **401** may provide virtual resources to any number of guest operating systems **410***a*, **410***b* (generally **410**). In some embodiments, a computing device **100** executes one or more types of hypervisors. In these embodiments, hypervisors may be used to emulate virtual hardware, partition physical hardware, virtualize physical hardware, and execute virtual machines that provide access to computing environments. Hypervisors may include those manufactured by VMWare, Inc., of Palo Alto, Calif.; the XEN hypervisor, an open source product whose development is overseen by the open source Xen.org community; HyperV, VirtualServer or virtual PC hypervisors provided by Microsoft, or others. In some embodiments, a computing device **100** executing a hypervisor that creates a virtual machine platform on which guest operating systems may execute is referred to as a host server. In one of these embodiments, for example, the computing device **100** is a XEN SERVER provided by Citrix Systems, Inc., of Fort Lauderdale, Fla.

In some embodiments, a hypervisor **401** executes within an operating system executing on a computing device. In one of these embodiments, a computing device executing an operating system and a hypervisor **401** may be said to have a host operating system (the operating system executing on the computing device), and a guest operating system (an operating system executing within a computing resource partition provided by the hypervisor **401**). In other embodiments, a hypervisor **401** interacts directly with hardware on a computing device, instead of executing on a host operating system. In one of these embodiments, the hypervisor **401** may be said to be executing on "bare metal," referring to the hardware comprising the computing device.

In some embodiments, a hypervisor **401** may create a virtual machine **406***a-c* (generally **406**) in which an operating system **410** executes. In one of these embodiments, for example, the hypervisor **401** loads a virtual machine image to create a virtual machine **406**. In another of these embodiments, the hypervisor **401** executes an operating system **410** within the virtual machine **406**. In still another of these embodiments, the virtual machine **406** executes an operating system **410**.

In some embodiments, the hypervisor **401** controls processor scheduling and memory partitioning for a virtual machine **406** executing on the computing device **100**. In one of these embodiments, the hypervisor **401** controls the execution of at least one virtual machine **406**. In another of these embodiments, the hypervisor **401** presents at least one virtual machine **406** with an abstraction of at least one hardware resource provided by the computing device **100**. In other embodiments, the hypervisor **401** controls whether and how physical processor capabilities are presented to the virtual machine **406**.

A control operating system **405** may execute at least one application for managing and configuring the guest operating systems. In one embodiment, the control operating system **405** may execute an administrative application, such as an application including a user interface providing administrators with access to functionality for managing the execution of a virtual machine, including functionality for executing a virtual machine, terminating an execution of a virtual machine, or identifying a type of physical resource for allocation to the virtual machine. In another embodiment, the hypervisor **401** executes the control operating system **405** within a virtual machine **406** created by the hypervisor **401**. In still another embodiment, the control operating system **405** executes in a virtual machine **406** that is authorized to directly access physical resources on the computing device **100**. In some embodiments, a control operating system **405***a* on a computing device **100***a* may exchange data with a control operating system **405***b* on a computing device **100***b*, via communications between a hypervisor **401***a* and a hypervisor **401***b*. In this way, one or more computing devices **100** may exchange data with one or more of the other computing devices **100** regarding processors and other physical resources available in a pool of resources. In one of these embodiments, this functionality allows a hypervisor to manage a pool of resources distributed across a plurality of physical computing devices. In another of these embodiments, multiple hypervisors manage one or more of the guest operating systems executed on one of the computing devices **100**.

In one embodiment, the control operating system **405** executes in a virtual machine **406** that is authorized to interact with at least one guest operating system **410**. In another embodiment, a guest operating system **410** communicates with the control operating system **405** via the hypervisor **401** in order to request access to a disk or a network. In still another embodiment, the guest operating system **410** and the control operating system **405** may communicate via a communication channel established by the hypervisor **401**, such as, for example, via a plurality of shared memory pages made available by the hypervisor **401**.

In some embodiments, the control operating system **405** includes a network back-end driver for communicating directly with networking hardware provided by the computing device **100**. In one of these embodiments, the network back-end driver processes at least one virtual machine request from at least one guest operating system **110**. In other embodiments, the control operating system **405** includes a block back-end driver for communicating with a storage element on the computing device **100**. In one of these embodiments, the block back-end driver reads and writes data from the storage element based upon at least one request received from a guest operating system **410**.

In one embodiment, the control operating system **405** includes a tools stack **404**. In another embodiment, a tools stack **404** provides functionality for interacting with the hypervisor **401**, communicating with other control operating systems **405** (for example, on a second computing device **100***b*), or managing virtual machines **406***b*, **406***c* on the computing device **100**. In another embodiment, the tools stack **404** includes customized applications for providing improved management functionality to an administrator of a virtual machine farm. In some embodiments, at least one of the tools stack **404** and the control operating system **405** include a management API that provides an interface for remotely configuring and controlling virtual machines **406** running on a computing device **100**. In other embodiments, the control operating system **405** communicates with the hypervisor **401** through the tools stack **104**.

In one embodiment, the hypervisor **401** executes a guest operating system **410** within a virtual machine **406** created by the hypervisor **401**. In another embodiment, the guest operating system **410** provides a user of the computing device **100** with access to resources within a computing environment. In still another embodiment, a resource includes a program, an application, a document, a file, a plurality of applications, a plurality of files, an executable program file, a desktop environment, a computing environment, or other resource made available to a user of the computing device **100**. In yet another embodiment, the resource may be delivered to the computing device **100** via a plurality of access methods including, but not limited to, conventional installation directly on the computing device **100**, delivery to the computing device **100** via a method for application streaming, delivery to the computing device **100** of output data generated by an execution of the resource on a second computing device **100'** and communicated to the computing device **100** via a presentation layer protocol, delivery to the computing device **100** of output data generated by an execution of the resource via a virtual machine executing on a second computing device **100'**, or execution from a removable storage device connected to the computing device **100**, such as a USB device, or via a virtual machine executing on the computing device **100** and generating output data. In some embodiments, the computing device **100** transmits output data generated by the execution of the resource to another computing device **100'**.

In one embodiment, the guest operating system **410**, in conjunction with the virtual machine on which it executes, forms a fully-virtualized virtual machine which is not aware that it is a virtual machine; such a machine may be referred to as a "Domain U HVM (Hardware Virtual Machine) virtual machine". In another embodiment, a fully-virtualized machine includes software emulating a Basic Input/Output System (BIOS) in order to execute an operating system within the fully-virtualized machine. In still another embodiment, a fully-virtualized machine may include a driver that provides functionality by communicating with the hypervisor **401**. In such an embodiment, the driver may be aware that it executes within a virtualized environment. In another embodiment, the guest operating system **410**, in conjunction with the virtual machine on which it executes, forms a paravirtualized virtual machine, which is aware that it is a virtual machine; such a machine may be referred to as a "Domain U PV virtual machine". In another embodiment, a paravirtualized machine includes additional drivers that a fully-virtualized machine does not include. In still another embodiment, the paravirtualized machine includes the network back-end driver and the block back-end driver included in a control operating system **405**, as described above.

Referring now to FIG. **4**B, a block diagram depicts one embodiment of a plurality of networked computing devices in a system in which at least one physical host executes a virtual machine. In brief overview, the system includes a management component **404** and a hypervisor **401**. The system includes a plurality of computing devices **100**, a plurality of virtual machines **406**, a plurality of hypervisors **401**, a plurality of management components referred to as tools stacks **404**, and a physical resource **421**, **428**. The plurality of physical machines **100** may each be provided as computing devices **100**, described above in connection with FIGS. **1**E-**1**H and **4**A.

In greater detail, a physical disk **428** is provided by a computing device **100** and stores at least a portion of a virtual disk **442**. In some embodiments, a virtual disk **442** is associated with a plurality of physical disks **428**. In one of these embodiments, one or more computing devices **100** may exchange data with one or more of the other computing devices **100** regarding processors and other physical resources available in a pool of resources, allowing a hypervisor to manage a pool of resources distributed across a plurality of physical computing devices. In some embodiments, a computing device **100** on which a virtual machine **406** executes is referred to as a physical host **100** or as a host machine **100**.

The hypervisor executes on a processor on the computing device **100**. The hypervisor allocates, to a virtual disk, an amount of access to the physical disk. In one embodiment, the hypervisor **401** allocates an amount of space on the physical disk. In another embodiment, the hypervisor **401** allocates a plurality of pages on the physical disk. In some embodiments, the hypervisor provisions the virtual disk **442** as part of a process of initializing and executing a virtual machine **450**.

In one embodiment, the management component **404***a* is referred to as a pool management component **404***a*. In another embodiment, a management operating system **405***a*, which may be referred to as a control operating system **405***a*, includes the management component. In some embodiments, the management component is referred to as a tools stack. In one of these embodiments, the management component is the tools stack **404** described above in connection with FIG. **4**A. In other embodiments, the management component **404** provides a user interface for receiving, from a user such as an administrator, an identification of a virtual machine **406** to provision and/or execute. In still other embodiments, the management component **404** provides a user interface for receiving, from a user such as an administrator, the request for migration of a virtual machine **406***b* from one physical machine **100** to another. In further embodiments, the management component **404***a* identifies a computing device **100***b* on which to execute a requested virtual machine **406***d* and instructs the hypervisor **401***b* on the identified computing device **100***b* to execute the identified virtual machine; such a management component may be referred to as a pool management component.

Referring now to FIG. **4**C, embodiments of a virtual application delivery controller or virtual appliance **450** are depicted. In brief overview, any of the functionality and/or embodiments of the appliance **200** (e.g., an application delivery controller) described above in connection with FIGS. **2**A and **2**B may be deployed in any embodiment of the virtualized environment described above in connection with FIGS. **4**A and **4**B. Instead of the functionality of the application delivery controller being deployed in the form of an appliance **200**, such functionality may be deployed in a virtualized environment **400** on any computing device **100**, such as a client **102**, server **106** or appliance **200**.

Referring now to FIG. **4**C, a diagram of an embodiment of a virtual appliance **450** operating on a hypervisor **401** of a server **106** is depicted. As with the appliance **200** of FIGS. **2**A and **2**B, the virtual appliance **450** may provide functionality for availability, performance, offload and security. For availability, the virtual appliance may perform load balancing between layers **4** and **7** of the network and may also perform intelligent service health monitoring. For performance increases via network traffic acceleration, the virtual appliance may perform caching and compression. To offload processing of any servers, the virtual appliance may perform connection multiplexing and pooling and/or SSL processing. For security, the virtual appliance may perform any of the application firewall functionality and SSL VPN function of appliance **200**.

Any of the modules of the appliance **200** as described in connection with FIG. **2**A may be packaged, combined, designed or constructed in a form of the virtualized appliance delivery controller **450** deployable as one or more software modules or components executable in a virtualized environment **300** or non-virtualized environment on any server, such as an off the shelf server. For example, the virtual appliance may be provided in the form of an installation package to install on a computing device. With reference to FIG. **2**A, any of the cache manager **232**, policy engine **236**, compression **238**, encryption engine **234**, packet engine **240**, GUI **210**, CLI **212**, shell services **214** and health monitoring programs **216** may be designed and constructed as a software component or module to run on any operating system of a computing device and/or of a virtualized environment **300**. Instead of using the encryption processor **260**, processor **262**, memory **264** and network stack **267** of the appliance **200**, the virtualized appliance **400** may use any of these resources as provided by the virtualized environment **400** or as otherwise available on the server **106**.

Still referring to FIG. **4**C, and in brief overview, any one or more vServers **275**A-**275**N may be in operation or executed in a virtualized environment **400** of any type of computing device **100**, such as any server **106**. Any of the modules or functionality of the appliance **200** described in connection with FIG. **2**B may be designed and constructed to operate in either a virtualized or non-virtualized environment of a server. Any of the vServer **275**, SSL VPN **280**, Intranet UP **282**, Switching **284**, DNS **286**, acceleration **288**, App FW **280** and monitoring agent may be packaged, combined, designed or constructed in a form of application delivery controller **450** deployable as one or more software modules or components executable on a device and/or virtualized environment **400**.

In some embodiments, a server may execute multiple virtual machines **406***a*-**406***n* in the virtualization environment with each virtual machine running the same or different embodiments of the virtual application delivery controller **450**. In some embodiments, the server may execute one or more virtual appliances **450** on one or more virtual machines on a core of a multi-core processing system. In some embodiments, the server may execute one or more virtual appliances **450** on one or more virtual machines on each processor of a multiple processor device.

E. Systems and Methods for Providing a Multi-Core Architecture

In accordance with Moore's Law, the number of transistors that may be placed on an integrated circuit may double approximately every two years. However, CPU speed increases may reach plateaus, for example CPU speed has been around 3.5-4 GHz range since 2005. In some cases, CPU manufacturers may not rely on CPU speed increases to gain additional performance. Some CPU manufacturers may add additional cores to their processors to provide additional performance. Products, such as those of software and networking vendors, that rely on CPUs for performance gains may improve their performance by leveraging these multi-core CPUs. The software designed and constructed for a single CPU may be redesigned and/or rewritten to take advantage of a multi-threaded, parallel architecture or otherwise a multi-core architecture.

A multi-core architecture of the appliance **200**, referred to as nCore or multi-core technology, allows the appliance in some embodiments to break the single core performance barrier and to leverage the power of multi-core CPUs. In the previous architecture described in connection with FIG. **2**A, a single network or packet engine is run. The multiple cores of the nCore technology and architecture allow multiple packet engines to run concurrently and/or in parallel. With a packet engine running on each core, the appliance architecture leverages the processing capacity of additional cores. In some embodiments, this provides up to a 7× increase in performance and scalability.

Illustrated in FIG. **5**A are some embodiments of work, task, load or network traffic distribution across one or more processor cores according to a type of parallelism or parallel computing scheme, such as functional parallelism, data parallelism or flow-based data parallelism. In brief overview, FIG. **5**A illustrates embodiments of a multi-core system such as an appliance **200'** with n-cores, a total of cores numbers 1 through N. In one embodiment, work, load or network traffic can be distributed among a first core **505**A, a second core **505**B, a third core **505**C, a fourth core **505**D, a fifth core **505**E, a sixth core **505**F, a seventh core **505**G, and so on such that distribution is across all or two or more of the n cores **505**N (hereinafter referred to collectively as cores **505**.) There may be multiple VIPs **275** each running on a respective core of the plurality of cores. There may be multiple packet engines **240** each running on a respective core of the plurality of cores. Any of the approaches used may lead to different, varying or similar work load or performance level **515** across any of the cores. For a functional parallelism approach, each core may run a different function of the functionalities provided by the packet engine, a VIP **275** or appliance **200**. In a data parallelism approach, data may be paralleled or distributed across the cores based on the Network Interface Card (NIC) or VIP **275** receiving the data. In another data parallelism approach, processing may be distributed across the cores by distributing data flows to each core.

In further detail to FIG. **5**A, in some embodiments, load, work or network traffic can be distributed among cores **505** according to functional parallelism **500**. Functional parallelism may be based on each core performing one or more respective functions. In some embodiments, a first core may perform a first function while a second core performs a second function. In functional parallelism approach, the functions to be performed by the multi-core system are divided and distributed to each core according to functionality. In some embodiments, functional parallelism may be referred to as task parallelism and may be achieved when each processor or core executes a different process or function on the same or different data. The core or processor may execute the same or different code. In some cases, different execution threads or code may communicate with one another as they work. Communication may take place to pass data from one thread to the next as part of a workflow.

In some embodiments, distributing work across the cores **505** according to functional parallelism **500**, can comprise distributing network traffic according to a particular function such as network input/output management (NW I/O) **510**A, secure sockets layer (SSL) encryption and decryption **510**B and transmission control protocol (TCP) functions **510**C. This may lead to a work, performance or computing load **515** based on a volume or level of functionality being used. In some embodiments, distributing work across the cores **505** according to data parallelism **540**, can comprise distributing an amount of work **515** based on distributing data associated with a particular hardware or software component. In some embodiments, distributing work across the cores **505** according to flow-based data parallelism **520**, can comprise distributing data based on a context or flow such that the amount of work **515**A-N on each core may be similar, substantially equal or relatively evenly distributed.

In the case of the functional parallelism approach, each core may be configured to run one or more functionalities of the plurality of functionalities provided by the packet engine or VIP of the appliance. For example, core **1** may perform network I/O processing for the appliance **200'** while core **2** performs TCP connection management for the appliance. Likewise, core **3** may perform SSL offloading while core **4** may perform layer 7 or application layer processing and traffic management. Each of the cores may perform the same function or different functions. Each of the cores may perform more than one function. Any of the cores may run any of the functionality or portions thereof identified and/or described in conjunction with FIGS. **2**A and **2**B. In this the approach, the work across the cores may be divided by function in either a coarse-grained or fine-grained manner. In some cases, as illustrated in FIG. **5**A, division by function may lead to different cores running at different levels of performance or load **515**.

In the case of the functional parallelism approach, each core may be configured to run one or more functionalities of the plurality of functionalities provided by the packet engine of the appliance. For example, core **1** may perform network I/O processing for the appliance **200'** while core **2** performs TCP connection management for the appliance. Likewise, core **3** may perform SSL offloading while core **4** may perform layer 7 or application layer processing and traffic management. Each of the cores may perform the same function or different functions. Each of the cores may perform more than one function. Any of the cores may run any of the functionality or portions thereof identified and/or described in conjunction with FIGS. **2**A and **2**B. In this the approach, the work across the cores may be divided by function in either a coarse-grained or fine-grained manner. In some cases, as illustrated in FIG. **5**A division by function may lead to different cores running at different levels of load or performance.

The functionality or tasks may be distributed in any arrangement and scheme. For example, FIG. **5**B illustrates a first core, Core **1** **505**A, processing applications and processes associated with network I/O functionality **510**A. Network traffic associated with network I/O, in some embodiments, can be associated with a particular port number. Thus, outgoing and incoming packets having a port destination associated with NW I/O **510**A will be directed towards Core **1** **505**A which is dedicated to handling all network traffic associated with the NW I/O port. Similarly, Core **2** **505**B is dedicated to handling functionality associated with SSL processing and Core **4** **505**D may be dedicated handling all TCP level processing and functionality.

While FIG. **5**A illustrates functions such as network I/O, SSL and TCP, other functions can be assigned to cores. These other functions can include any one or more of the functions or operations described herein. For example, any of the functions described in conjunction with FIGS. **2**A and **2**B may be distributed across the cores on a functionality basis. In some cases, a first VIP **275**A may run on a first core while a second VIP **275**B with a different configuration may run on a second core. In some embodiments, each core **505** can handle a particular functionality such that each core **505** can handle the processing associated with that particular function. For example, Core **2** **505**B may handle SSL offloading while Core **4** **505**D may handle application layer processing and traffic management.

In other embodiments, work, load or network traffic may be distributed among cores **505** according to any type and form of data parallelism **540**. In some embodiments, data parallelism may be achieved in a multi-core system by each core performing the same task or functionally on different pieces of distributed data. In some embodiments, a single execution thread or code controls operations on all pieces of data. In other embodiments, different threads or instructions control the operation, but may execute the same code. In some embodiments, data parallelism is achieved from the perspective of a packet engine, vServers (VIPs) **275**A-C, network interface cards (NIC) **542**D-E and/or any other networking hardware or software included on or associated with an appliance **200**. For example, each core may run the same packet engine or VIP code or configuration but operate on different sets of distributed data. Each networking hardware or software construct can receive different, varying or substantially the same amount of data, and as a result may have varying, different or relatively the same amount of load **515**

In the case of a data parallelism approach, the work may be divided up and distributed based on VIPs, NICs and/or data flows of the VIPs or NICs. In one of these approaches, the work of the multi-core system may be divided or distributed among the VIPs by having each VIP work on a distributed set of data. For example, each core may be configured to run one or more VIPs. Network traffic may be distributed to the core for each VIP handling that traffic. In another of these approaches, the work of the appliance may be divided or distributed among the cores based on which NIC receives the network traffic. For example, network traffic of a first NIC may be distributed to a first core while network traffic of a second NIC may be distributed to a second core. In some cases, a core may process data from multiple NICs.

While FIG. **5**A illustrates a single vServer associated with a single core **505**, as is the case for VIP**1** **275**A, VIP**2** **275**B and VIP**3** **275**C. In some embodiments, a single vServer can be associated with one or more cores **505**. In contrast, one or more vServers can be associated with a single core **505**. Associating a vServer with a core **505** may include that core **505** to process all functions associated with that particular vServer. In some embodiments, each core executes a VIP having the same code and configuration. In other embodiments, each core executes a VIP having the same code but different configuration. In some embodiments, each core executes a VIP having different code and the same or different configuration.

Like vServers, NICs can also be associated with particular cores **505**. In many embodiments, NICs can be connected to one or more cores **505** such that when a NIC receives or transmits data packets, a particular core **505** handles the processing involved with receiving and transmitting the data packets. In one embodiment, a single NIC can be associated with a single core **505**, as is the case with NIC**1** **542**D and NIC**2** **542**E. In other embodiments, one or more NICs can be associated with a single core **505**. In other embodiments, a single NIC can be associated with one or more cores **505**. In these embodiments, load could be distributed amongst the one or more cores **505** such that each core **505** processes a substantially similar amount of load. A core **505** associated with a NIC may process all functions and/or data associated with that particular NIC.

While distributing work across cores based on data of VIPs or NICs may have a level of independency, in some embodiments, this may lead to unbalanced use of cores as illustrated by the varying loads **515** of FIG. **5**A.

In some embodiments, load, work or network traffic can be distributed among cores **505** based on any type and form of data flow. In another of these approaches, the work may be divided or distributed among cores based on data flows. For example, network traffic between a client and a server traversing the appliance may be distributed to and processed by one core of the plurality of cores. In some cases, the core initially establishing the session or connection may be the core for which network traffic for that session or connection is distributed. In some embodiments, the data flow is based on any unit or portion of network traffic, such as a transaction, a request/response communication or traffic originating from an application on a client. In this manner and in some embodiments, data flows between clients and servers traversing the appliance **200'** may be distributed in a more balanced manner than the other approaches.

In flow-based data parallelism **520**, distribution of data is related to any type of flow of data, such as request/response pairings, transactions, sessions, connections or application communications. For example, network traffic between a client and a server traversing the appliance may be distributed to and processed by one core of the plurality of cores. In some cases, the core initially establishing the session or connection may be the core for which network traffic for that session or connection is distributed. The distribution of data flow may be such that each core **505** carries a substantially equal or relatively evenly distributed amount of load, data or network traffic.

In some embodiments, the data flow is based on any unit or portion of network traffic, such as a transaction, a request/response communication or traffic originating from an application on a client. In this manner and in some embodiments, data flows between clients and servers traversing the appliance **200'** may be distributed in a more balanced manner than the other approached. In one embodiment, data flow can be distributed based on a transaction or a series of transactions. This transaction, in some embodiments, can be between a client and a server and can be characterized by an IP address or other packet identifier. For example, Core **1** **505**A can be dedicated to transactions between a particular client and a particular server, therefore the load **536**A on Core **1** **505**A may be comprised of the network traffic associated with the transactions between the particular client and server. Allocating the network traffic to Core **1** **505**A can be accomplished by routing all data packets originating from either the particular client or server to Core **1** **505**A.

While work or load can be distributed to the cores based in part on transactions, in other embodiments load or work can be allocated on a per packet basis. In these embodiments, the appliance **200** can intercept data packets and allocate them to a core **505** having the least amount of load. For example, the appliance **200** could allocate a first incoming data packet to Core **1** **505**A because the load **536**A on Core **1** is less than the load **536**B-N on the rest of the cores **505**B-N. Once the first data packet is allocated to Core **1** **505**A, the amount of load **536**A on Core **1** **505**A is increased proportional to the amount of processing resources needed to process the first data packet. When the appliance **200** intercepts a second data packet, the appliance **200** will allocate the load to Core **4** **505**D because Core **4** **505**D has the second least amount of load. Allocating data packets to the core with the least amount of load can, in some embodiments, ensure that the load **536**A-N distributed to each core **505** remains substantially equal.

In other embodiments, load can be allocated on a per unit basis where a section of network traffic is allocated to a particular core **505**. The above-mentioned example illustrates load balancing on a per/packet basis. In other embodiments, load can be allocated based on a number of packets such that every 10, 100 or 1000 packets are allocated to the core **505** having the least amount of load. The number of packets allocated to a core **505** can be a number determined by an application, user or administrator and can be any number greater than zero. In still other embodiments, load can be allocated based on a time metric such that packets are distributed to a particular core **505** for a predetermined amount of time. In these embodiments, packets can be distributed to a particular core **505** for five milliseconds or for any period of time determined by a user, program, system, administrator or otherwise. After the predetermined time period elapses, data packets are transmitted to a different core **505** for the predetermined period of time.

Flow-based data parallelism methods for distributing work, load or network traffic among the one or more cores **505** can comprise any combination of the above-mentioned embodiments. These methods can be carried out by any part of the appliance **200**, by an application or set of executable instructions executing on one of the cores **505**, such as the packet engine, or by any application, program or agent executing on a computing device in communication with the appliance **200**.

The functional and data parallelism computing schemes illustrated in FIG. **5**A can be combined in any manner to generate a hybrid parallelism or distributed processing scheme that encompasses function parallelism **500**, data parallelism **540**, flow-based data parallelism **520** or any portions thereof. In some cases, the multi-core system may use any type and form of load balancing schemes to distribute load among the one or more cores **505**. The load balancing scheme may be used in any combination with any of the functional and data parallelism schemes or combinations thereof.

Illustrated in FIG. **5**B is an embodiment of a multi-core system **545**, which may be any type and form of one or more systems, appliances, devices or components. This system **545**, in some embodiments, can be included within an appliance **200** having one or more processing cores **505**A-N. The system **545** can further include one or more packet engines (PE) or packet processing engines (PPE) **548**A-N communicating with a memory bus **556**. The memory bus may be used to communicate with the one or more processing cores **505**A-N. Also included within the system **545** can be one or more network interface cards (NIC) **552** and a flow distributor **550** which can further communicate with the one or more processing cores **505**A-N. The flow distributor **550** can comprise a Receive Side Scaler (RSS) or Receive Side Scaling (RSS) module **560**.

Further referring to FIG. **5**B, and in more detail, in one embodiment the packet engine(s) **548**A-N can comprise any portion of the appliance **200** described herein, such as any portion of the appliance described in FIGS. **2**A and **2**B. The packet engine(s) **548**A-N can, in some embodiments, comprise any of the following elements: the packet engine **240**, a network stack **267**; a cache manager **232**; a policy engine **236**; a compression engine **238**; an encryption engine **234**; a GUI **210**; a CLI **212**; shell services **214**; monitoring programs **216**; and any other software or hardware element able to receive data packets from one of either the memory bus **556** or the one of more cores **505**A-N. In some embodiments, the packet engine(s) **548**A-N can comprise one or more vServers **275**A-N, or any portion thereof. In other embodiments, the packet engine(s) **548**A-N can provide any combination of the following functionalities: SSL VPN **280**; Intranet UP **282**; switching **284**; DNS **286**; packet acceleration **288**; App FW **280**; monitoring such as the monitoring provided by a monitoring agent **197**; functionalities associated with functioning as a TCP stack; load balancing; SSL offloading and processing; content switching; policy evaluation; caching; compression; encoding; decompression; decoding; application firewall functionalities; XML processing and acceleration; and SSL VPN connectivity.

The packet engine(s) **548**A-N can, in some embodiments, be associated with a particular server, user, client or network. When a packet engine **548** becomes associated with a particular entity, that packet engine **548** can process data packets associated with that entity. For example, should a packet engine **548** be associated with a first user, that packet engine **548** will process and operate on packets generated by the first user, or packets having a destination address associated with the first user. Similarly, the packet engine **548** may choose not to be associated with a particular entity such that the packet engine **548** can process and otherwise operate on any data packets not generated by that entity or destined for that entity.

In some instances, the packet engine(s) **548**A-N can be configured to carry out the any of the functional and/or data parallelism schemes illustrated in FIG. **5**A. In these instances, the packet engine(s) **548**A-N can distribute functions or data among the processing cores **505**A-N so that the distribution is according to the parallelism or distribution scheme. In some embodiments, a single packet engine(s) **548**A-N carries out a load balancing scheme, while in other embodiments one or more packet engine(s) **548**A-N carry out a load balancing scheme. Each core **505**A-N, in one embodiment, can be associated with a particular packet engine **505** such that load balancing can be carried out by the packet engine **505**. Load balancing may in this embodiment, require that each packet engine **505** associated with a core **505** communicate with the other packet engines **505** associated with cores **505** so that the packet engines **505** can collectively determine where to distribute load. One embodiment of this process can include an arbiter that receives votes from each packet engine **505** for load. The arbiter can distribute load to each packet engine **505** based in part on the age of the engine's vote and in some cases a priority value associated with the current amount of load on an engine's associated core **505**.

Any of the packet engines running on the cores may run in user mode, kernel or any combination thereof. In some embodiments, the packet engine operates as an application or program running is user or application space. In these embodiments, the packet engine may use any type and form of interface to access any functionality provided by the kernel. In some embodiments, the packet engine operates in kernel mode or as part of the kernel. In some embodiments, a first portion of the packet engine operates in user mode while a second portion of the packet engine operates in kernel mode. In some embodiments, a first packet engine on a first core executes in kernel mode while a second packet engine on a second core executes in user mode. In some embodiments, the packet engine or any portions thereof operates on or in conjunction with the NIC or any drivers thereof.

In some embodiments the memory bus **556** can be any type and form of memory or computer bus. While a single memory bus **556** is depicted in FIG. **5**B, the system **545** can comprise any number of memory buses **556**. In one embodiment, each packet engine **548** can be associated with one or more individual memory buses **556**.

The NIC **552** can in some embodiments be any of the network interface cards or mechanisms described herein. The NIC **552** can have any number of ports. The NIC can be designed and constructed to connect to any type and form of network **104**. While a single NIC **552** is illustrated, the system **545** can comprise any number of NICs **552**. In some embodiments, each core **505**A-N can be associated with one or more single NICs **552**. Thus, each core **505** can be associated with a single NIC **552** dedicated to a particular core **505**. The cores **505**A-N can comprise any of the processors described herein. Further, the cores **505**A-N can be configured according to any of the core **505** configurations described herein. Still further, the cores **505**A-N can have any of the core **505** functionalities described herein. While FIG. **5**B illustrates seven cores **505**A-G, any number of cores **505** can be included within the system **545**. In particular, the system **545** can comprise "N" cores, where "N" is a whole number greater than zero.

A core may have or use memory that is allocated or assigned for use to that core. The memory may be considered private or local memory of that core and only accessible by that core. A core may have or use memory that is shared or assigned to multiple cores. The memory may be considered public or shared memory that is accessible by more than one core. A core may use any combination of private and public memory. With separate address spaces for each core, some level of coordination is eliminated from the case of using the same address space. With a separate address space, a core can perform work on information and data in the core's own address space without worrying about conflicts with other cores. Each packet engine may have a separate memory pool for TCP and/or SSL connections.

Further referring to FIG. **5**B, any of the functionality and/or embodiments of the cores **505** described above in connection with FIG. **5**A can be deployed in any embodiment of the virtualized environment described above in connection with FIGS. **4**A and **4**B. Instead of the functionality of the cores **505** being deployed in the form of a physical processor **505**, such functionality may be deployed in a virtualized environment **400** on any computing device **100**, such as a client **102**, server **106** or appliance **200**. In other embodiments, instead of the functionality of the cores **505** being deployed in the form of an appliance or a single device, the functionality may be deployed across multiple devices in any arrangement. For example, one device may comprise two or more cores and another device may comprise two or more cores. For example, a multi-core system may include a cluster of computing devices, a server farm or network of computing devices. In some embodiments, instead of the functionality of the cores **505** being deployed in the form of cores, the functionality may be deployed on a plurality of processors, such as a plurality of single core processors.

In one embodiment, the cores **505** may be any type and form of processor. In some embodiments, a core can function substantially similar to any processor or central processing unit described herein. In some embodiment, the cores **505** may comprise any portion of any processor described herein. While FIG. **5**A illustrates seven cores, there can exist any "N" number of cores within an appliance **200**, where "N" is any whole number greater than one. In some embodiments, the cores **505** can be installed within a common appliance **200**, while in other embodiments the cores **505** can be installed within one or more appliance(s) **200** communicatively connected to one another. The cores **505** can in some embodiments comprise graphics processing software, while in other embodiments the cores **505** provide general processing capabilities. The cores **505** can be installed physically near each other and/or can be communicatively connected to each other. The cores may be connected by any type and form of bus or subsystem physically and/or communicatively coupled to the cores for transferring data between to, from and/or between the cores.

While each core **505** can comprise software for communicating with other cores, in some embodiments a core manager (Not Shown) can facilitate communication between each core **505**. In some embodiments, the kernel may provide core management. The cores may interface or communicate with each other using a variety of interface mechanisms. In some embodiments, core to core messaging may be used to communicate between cores, such as a first core sending a message or data to a second core via a bus or subsystem connecting the cores. In some embodiments, cores may communicate via any type and form of shared memory interface. In one embodiment, there may be one or more memory locations shared among all the cores. In some embodiments, each core may have separate memory locations shared with each other core. For example, a first core may have a first shared memory with a second core and a second share memory with a third core. In some embodiments, cores may communicate via any type of programming or API, such as function calls via the kernel. In some embodiments, the operating system may recognize and support multiple core devices and provide interfaces and API for inter-core communications.

The flow distributor **550** can be any application, program, library, script, task, service, process or any type and form of executable instructions executing on any type and form of hardware. In some embodiments, the flow distributor **550** may any design and construction of circuitry to perform any of the operations and functions described herein. In some embodiments, the flow distributor distribute, forwards, routes, controls and/ors manage the distribution of data packets among the cores **505** and/or packet engine or VIPs running on the cores. The flow distributor **550**, in some embodiments, can be referred to as an interface master. In one embodiment, the flow distributor **550** comprises a set of executable instructions executing on a core or processor of the appliance **200**. In another embodiment, the flow distributor **550** comprises a set of executable instructions executing on a computing machine in communication with the appliance **200**. In some embodiments, the flow distributor **550** comprises a set of executable instructions executing on a NIC, such as firmware. In still other embodiments, the flow distributor **550** comprises any combination of software and hardware to distribute data packets among cores or processors. In one embodiment, the flow distributor **550** executes on at least one of the cores **505**A-N, while in other embodiments a separate flow distributor **550** assigned to each core **505**A-N executes on an associated core **505**A-N. The flow distributor may use any type and form of statistical or probabilistic algorithms or decision making to balance the flows across the cores. The hardware of the appliance, such as a NIC, or the kernel may be designed and constructed to support sequential operations across the NICs and/or cores.

In embodiments where the system **545** comprises one or more flow distributors **550**, each flow distributor **550** can be associated with a processor **505** or a packet engine **548**. The flow distributors **550** can comprise an interface mechanism that allows each flow distributor **550** to communicate with the other flow distributors **550** executing within the system **545**. In one instance, the one or more flow distributors **550** can determine how to balance load by communicating with each other. This process can operate substantially similarly to the process described above for submitting votes to an arbiter which then determines which flow distributor **550** should receive the load. In other embodiments, a first flow distributor

550' can identify the load on an associated core and determine whether to forward a first data packet to the associated core based on any of the following criteria: the load on the associated core is above a predetermined threshold; the load on the associated core is below a predetermined threshold; the load on the associated core is less than the load on the other cores; or any other metric that can be used to determine where to forward data packets based in part on the amount of load on a processor.

The flow distributor **550** can distribute network traffic among the cores **505** according to a distribution, computing or load balancing scheme such as those described herein. In one embodiment, the flow distributor can distribute network traffic or; pad according to any one of a functional parallelism distribution scheme **550**, a data parallelism load distribution scheme **540**, a flow-based data parallelism distribution scheme **520**, or any combination of these distribution scheme or any load balancing scheme for distributing load among multiple processors. The flow distributor **550** can therefore act as a load distributor by taking in data packets and distributing them across the processors according to an operative load balancing or distribution scheme. In one embodiment, the flow distributor **550** can comprise one or more operations, functions or logic to determine how to distribute packers, work or load accordingly. In still other embodiments, the flow distributor **550** can comprise one or more sub operations, functions or logic that can identify a source address and a destination address associated with a data packet, and distribute packets accordingly.

In some embodiments, the flow distributor **550** can comprise a receive-side scaling (RSS) network driver, module **560** or any type and form of executable instructions which distribute data packets among the one or more cores **505**. The RSS module **560** can comprise any combination of hardware and software, In some embodiments, the RSS module **560** works in conjunction with the flow distributor **550** to distribute data packets across the cores **505**A-N or among multiple processors in a multi-processor network. The RSS module **560** can execute within the NIC **552** in some embodiments, and in other embodiments can execute on any one of the cores **505**.

In some embodiments, the RSS module **560** uses the MICROSOFT receive-side-scaling (RSS) scheme. In one embodiment, RSS is a Microsoft Scalable Networking initiative technology that enables receive processing to be balanced across multiple processors in the system while maintaining in-order delivery of the data. The RSS may use any type and form of hashing scheme to determine a core or processor for processing a network packet.

The RSS module **560** can apply any type and form hash function such as the Toeplitz hash function. The hash function may be applied to the hash type or any the sequence of values. The hash function may be a secure hash of any security level or is otherwise cryptographically secure. The has function may use a hash key. The size of the key is dependent upon the hash function. For the Toeplitz hash, the size may be 40 bytes for IPv6 and 16 bytes for IPv4.

The hash function may be designed and constructed based on any one or more criteria or design goals. In some embodiments, a hash function may be used that provides an even distribution of hash result for different hash inputs and different hash types, including TCP/IPv4, TCP/IPv6, IPv4, and IPv6 headers. In some embodiments, a hash function may be used that provides a hash result that is evenly distributed when a small number of buckets are present (for example, two or four). In some embodiments, hash function may be used that provides a hash result that is randomly distributed when a large number of buckets were present (for example, 64 buckets). In some embodiments, the hash function is determined based on a level of computational or resource usage. In some embodiments, the hash function is determined based on ease or difficulty of implementing the hash in hardware. In some embodiments, the hash function is determined bases on the ease or difficulty of a malicious remote host to send packets that would all hash to the same bucket.

The RSS may generate hashes from any type and form of input, such as a sequence of values. This sequence of values can include any portion of the network packet, such as any header, field or payload of network packet, or portions thereof. In some embodiments, the input to the hash may be referred to as a hash type and include any tuples of information associated with a network packet or data flow, such as any of the following: a four tuple comprising at least two IP addresses and two ports; a four tuple comprising any four sets of values; a six tuple; a two tuple; and/or any other sequence of numbers or values. The following are example of hash types that may be used by RSS:

- 4-tuple of source TCP Port, source IP version 4 (IPv4) address, destination TCP Port, and destination IPv4 address. This is the only required hash type to support.
- 4-tuple of source TCP Port, source IP version 6 (IPv6) address, destination TCP Port, and destination IPv6 address.
- 2-tuple of source IPv4 address, and destination IPv4 address.
- 2-tuple of source IPv6 address, and destination IPv6 address.
- 2-tuple of source IPv6 address, and destination IPv6 address, including support for parsing IPv6 extension headers.

The hash result or any portion thereof may used to identify a core or entity, such as a packet engine or VIP, for distributing a network packet. In some embodiments, one or more hash bits or mask are applied to the hash result. The hash bit or mask may be any number of bits or bytes. A NIC may support any number of bits, such as seven bits. The network stack may set the actual number of bits to be used during initialization. The number will be between 1 and 7, inclusive.

The hash result may be used to identify the core or entity via any type and form of table, such as a bucket table or indirection table. In some embodiments, the number of hash-result bits are used to index into the table. The range of the hash mask may effectively define the size of the indirection table. Any portion of the hash result or the hash result itself may be used to index the indirection table. The values in the table may identify any of the cores or processor, such as by a core or processor identifier. In some embodiments, all of the cores of the multi-core system are identified in the table. In other embodiments, a port of the cores of the multi-core system are identified in the table. The indirection table may comprise any number of buckets for example 2 to 128 buckets that may be indexed by a hash mask. Each bucket may comprise a range of index values that identify a core or processor. In some embodiments, the flow controller and/or RSS module may rebalance the network rebalance the network load by changing the indirection table.

In some embodiments, the multi-core system **575** does not include a RSS driver or RSS module **560**. In some of these embodiments, a software steering module (Not Shown) or a software embodiment of the RSS module within the system can operate in conjunction with or as part of the flow distributor **550** to steer packets to cores **505** within the multi-core system **575**.

The flow distributor **550**, in some embodiments, executes within any module or program on the appliance **200**, on any one of the cores **505** and on any one of the devices or components included within the multi-core system **575**. In some embodiments, the flow distributor **550'** can execute on the first core **505**A, while in other embodiments the flow distributor **550"** can execute on the NIC **552**. In still other embodiments, an instance of the flow distributor **550'** can execute on each core **505** included in the multi-core system **575**. In this embodiment, each instance of the flow distributor **550'** can communicate with other instances of the flow distributor **550'** to forward packets back and forth across the cores **505**. There exist situations where a response to a request packet may not be processed by the same core, i.e. the first core processes the request while the second core processes the response. In these situations, the instances of the flow distributor **550'** can intercept the packet and forward it to the desired or correct core **505**, i.e. a flow distributor instance **550'** can forward the response to the first core. Multiple instances of the flow distributor **550'** can execute on any number of cores **505** and any combination of cores **505**.

The flow distributor may operate responsive to any one or more rules or policies. The rules may identify a core or packet processing engine to receive a network packet, data or data flow. The rules may identify any type and form of tuple information related to a network packet, such as a 4-tuple of source and destination IP address and source and destination ports. Based on a received packet matching the tuple specified by the rule, the flow distributor may forward the packet to a core or packet engine. In some embodiments, the packet is forwarded to a core via shared memory and/or core to core messaging.

Although FIG. **5**B illustrates the flow distributor **550** as executing within the multi-core system **575**, in some embodiments the flow distributor **550** can execute on a computing device or appliance remotely located from the multi-core system **575**. In such an embodiment, the flow distributor **550** can communicate with the multi-core system **575** to take in data packets and distribute the packets across the one or more cores **505**. The flow distributor **550** can, in one embodiment, receive data packets destined for the appliance **200**, apply a distribution scheme to the received data packets and distribute the data packets to the one or more cores **505** of the multi-core system **575**. In one embodiment, the flow distributor **550** can be included in a router or other appliance such that the router can target particular cores **505** by altering meta data associated with each packet so that each packet is targeted towards a sub-node of the multi-core system **575**. In such an embodiment, CISCO's vn-tag mechanism can be used to alter or tag each packet with the appropriate meta data.

Illustrated in FIG. **5**C is an embodiment of a multi-core system **575** comprising one or more processing cores **505**A-N. In brief overview, one of the cores **505** can be designated as a control core **505**A and can be used as a control plane **570** for the other cores **505**. The other cores may be secondary cores which operate in a data plane while the control core provides the control plane. The cores **505**A-N may share a global cache **580**. While the control core provides a control plane, the other cores in the multi-core system form or provide a data plane. These cores perform data processing functionality on network traffic while the control provides initialization, configuration and control of the multi-core system. Further referring to FIG. **5**C, and in more detail, the cores **505**A-N as well as the control core **505**A can be any processor described herein. Furthermore, the cores **505**A-N and the control core **505**A can be any processor able to function within the system **575** described in FIG. **5**C. Still further, the cores **505**A-N and the control core **505**A can be any core or group of cores described herein. The control core may be a different type of core or processor than the other cores. In some embodiments, the control may operate a different packet engine or have a packet engine configured differently than the packet engines of the other cores.

Any portion of the memory of each of the cores may be allocated to or used for a global cache that is shared by the cores. In brief overview, a predetermined percentage or predetermined amount of each of the memory of each core may be used for the global cache. For example, 50% of each memory of each code may be dedicated or allocated to the shared global cache. That is, in the illustrated embodiment, 2 GB of each core excluding the control plane core or core **1** may be used to form a 28 GB shared global cache. The configuration of the control plane such as via the configuration services may determine the amount of memory used for the shared global cache. In some embodiments, each core may provide a different amount of memory for use by the global cache. In other embodiments, any one core may not provide any memory or use the global cache. In some embodiments, any of the cores may also have a local cache in memory not allocated to the global shared memory. Each of the cores may store any portion of network traffic to the global shared cache. Each of the cores may check the cache for any content to use in a request or response. Any of the cores may obtain content from the global shared cache to use in a data flow, request or response.

The global cache **580** can be any type and form of memory or storage element, such as any memory or storage element described herein. In some embodiments, the cores **505** may have access to a predetermined amount of memory (i.e. 32 GB or any other memory amount commensurate with the system **575**.) The global cache **580** can be allocated from that predetermined amount of memory while the rest of the available memory can be allocated among the cores **505**. In other embodiments, each core **505** can have a predetermined amount of memory. The global cache **580** can comprise an amount of the memory allocated to each core **505**. This memory amount can be measured in bytes, or can be measured as a percentage of the memory allocated to each core **505**. Thus, the global cache **580** can comprise 1 GB of memory from the memory associated with each core **505**, or can comprise 20 percent or one-half of the memory associated with each core **505**. In some embodiments, only a portion of the cores **505** provide memory to the global cache **580**, while in other embodiments the global cache **580** can comprise memory not allocated to the cores **505**.

Each core **505** can use the global cache **580** to store network traffic or cache data. In some embodiments, the packet engines of the core use the global cache to cache and use data stored by the plurality of packet engines. For example, the cache manager of FIG. **2**A and cache functionality of FIG. **2**B may use the global cache to share data for acceleration. For example, each of the packet engines may store responses, such as HTML data, to the global cache. Any of the cache managers operating on a core may access the global cache to server caches responses to client requests.

In some embodiments, the cores **505** can use the global cache **580** to store a port allocation table which can be used to determine data flow based in part on ports. In other embodiments, the cores **505** can use the global cache **580** to store an address lookup table or any other table or list that can be used by the flow distributor to determine where to direct incoming and outgoing data packets. The cores **505** can, in some embodiments read from and write to cache **580**, while in other embodiments the cores **505** can only read from or write to cache **580**. The cores may use the global cache to perform core to core communications.

The global cache **580** may be sectioned into individual memory sections where each section can be dedicated to a particular core **505**. In one embodiment, the control core **505**A can receive a greater amount of available cache, while the other cores **505** can receiving varying amounts or access to the global cache **580**.

In some embodiments, the system **575** can comprise a control core **505**A. While FIG. **5**C illustrates core **1 505**A as the control core, the control core can be any core within the appliance **200** or multi-core system. Further, while only a single control core is depicted, the system **575** can comprise one or more control cores each having a level of control over the system. In some embodiments, one or more control cores can each control a particular aspect of the system **575**. For example, one core can control deciding which distribution scheme to use, while another core can determine the size of the global cache **580**.

The control plane of the multi-core system may be the designation and configuration of a core as the dedicated management core or as a master core. This control plane core may provide control, management and coordination of operation and functionality the plurality of cores in the multi-core system. This control plane core may provide control, management and coordination of allocation and use of memory of the system among the plurality of cores in the multi-core system, including initialization and configuration of the same. In some embodiments, the control plane includes the flow distributor for controlling the assignment of data flows to cores and the distribution of network packets to cores based on data flows. In some embodiments, the control plane core runs a packet engine and in other embodiments, the control plane core is dedicated to management and control of the other cores of the system.

The control core **505**A can exercise a level of control over the other cores **505** such as determining how much memory should be allocated to each core **505** or determining which core **505** should be assigned to handle a particular function or hardware/software entity. The control core **505**A, in some embodiments, can exercise control over those cores **505** within the control plan **570**. Thus, there can exist processors outside of the control plane **570** which are not controlled by the control core **505**A. Determining the boundaries of the control plane **570** can include maintaining, by the control core **505**A or agent executing within the system **575**, a list of those cores **505** controlled by the control core **505**A. The control core **505**A can control any of the following: initialization of a core; determining when a core is unavailable; re-distributing load to other cores **505** when one core fails; determining which distribution scheme to implement; determining which core should receive network traffic; determining how much cache should be allocated to each core; determining whether to assign a particular function or element to a particular core; determining whether to permit cores to communicate with one another; determining the size of the global cache **580**; and any other determination of a function, configuration or operation of the cores within the system **575**.

F. Systems and Methods for Dynamic Connection Spillover

Referring now to FIG. **6**, an embodiment of a system for providing management of transport layer connections via an appliance using a dynamic maximum connection threshold is depicted. In brief overview, the appliance **200** establishes a first vServer **275**A to load balance **284** a plurality of clients **102***a*-**102***n* access to one or more services **270**A-**270**N of a first set of servers **106**A-**106**N. The appliance **200** includes a connection management mechanism **610** for managing and balancing transport layer connection requests from clients **102***a*-**102***n* to one or more set of services **270**A-**270**N. The appliance **200** establishes for the first vServer **275**A a maximum dynamic connection threshold **1020**A based on the sum of the connection capacity **625**A-**625**N each of the services **270**A-**270**N are targeted or configured to handle. Via monitoring agents **420**A-**420**N, the appliance monitors the operational status of each of the services **270**A-**270**N. If any of the services **270**A-**270**N have a change in status from available to not available, or not available to available, the appliance **200** adjusts the dynamic maximum connection threshold **1020**A by including or not including the corresponding connection capacity **625**A-**625**B of the service in the summation of the threshold. For example, if the appliance **200** detects a first service **270**A has a status of not available, the appliance **200** subtracts the connection capacity **625**A of the first service **270**A from the maximum dynamic connection threshold **1020**A. As such, the appliance **200** dynamically adjusts the maximum connection threshold **1020** for a vServer **275** in real-time in accordance with the monitored status of the services **270**A-**270**N and each service's corresponding connection capacity **625**A-**625**N.

In further detail, the connection management mechanism **610** comprises software, hardware, or any combination of software and hardware having logic, functions or operations for receiving and managing connection requests and communications from one or more clients **102**A-**102**N. In one embodiment, the connection management mechanism **610** receives or intercepts transport layer connection requests and communications between the clients **102**A-**102**N and one or more services **270**A-**270**N. The connection management mechanism **610** may include an application, program, service, process, task, thread or any type and form of executable instructions. In another embodiment, the connection management mechanism **610** identifies, determines or selects a vServer **275** for processing a received communication from a client **102**.

In some embodiments, the connection management mechanism **610** determines if the dynamic maximum connection threshold **1020** has been reached or exceeded. The connection management mechanism **610** determines if the dynamic maximum connection threshold is exceeded, and whether or not to establish a backup or second vServer **275**N, e.g., a spillover vServer. Upon detecting the number of active transport layer connections of the first vServer **275**A exceeds the dynamically adjusted maximum connection threshold **1020**, the connection management mechanism **610** may direct, transfer or otherwise provide a received transport layer connection request of a client **102** to the second vServer **275**N for handling. By using the dynamically adjusted maximum connection threshold **1020**, the connection management mechanism **610** dynamically and automatically spillovers connection requests from clients **102** from a first vServer **275**A to a backup or second vServer **275**N.

In other embodiments, the connection management mechanism **610** may maintain connection or session persistence between a client **102** and the vServer **275**A-**275**N handling requests for the client **102**. In some embodiments, the connection management mechanism **610** selects the spillover vServer **275**N for handling a client request even though the number of active connections of the first vServer **275**A does not exceed the maximum connection threshold **1020**. In other embodiments, the connection management mechanism **610** selects the first vServer **275**A for handling a client request event though requests from other clients are directed to the spillover vServer **275**N. In one embodiment, the connection management mechanism **610** may select the first vServer **275**A or second vServer **275**N based on which vServer **275** most recently handled a request from the client **102**.

Upon detecting the dynamically adjusted maximum connection threshold **1020** has been exceeded for the first vServer **275**A and/or the second vServer **275**N, the connection management mechanism **610**, in one embodiment, may determine not to establish another spillover vServer **275**N but instead redirects the client **102** directly to a server **106** or otherwise to bypass the appliance **200**. For example, the connection management mechanism **610** may determine the dynamically adjusted maximum connection threshold **1020**B for the spillover vServer **275**N has been reached and may redirect the client **102** to bypass the appliance **200** instead of establishing a third vServer **275**N for spillover. In these embodiments, the connection management mechanism **610** may transmit a redirect Uniform Resource Locator (URL) **660** to the client **102** for the client **102** to connect to in response to the client's connection request. The URL **660** may identify any one of the servers **106** or services **270**.

In yet another embodiment, the appliance **200** and/or connection management mechanism **610** manages the number of active connections and performs dynamic spillover techniques for a plurality of vServers **275**A-**275**N. In one embodiment, the second vServer **275**B may be managing connections from a plurality of clients **102**A-**102**N to a second set of services **270**A'-**270**N'. In some embodiments, the appliance **200** monitors a second dynamic maximum connection threshold **1020**B for a second vServer **275**B. In one embodiment, the second vServer **275**B may be acting as a spillover vServer for the first vServer **275**N or a third vServer.

The connection capacity **625** for a service **270** comprises a predetermined number of clients, transport layer connections or users a service **270** is designed, configured or intended to handle or process. In some embodiments, the connection capacity **625** comprises a maximum number of clients, connections or users **625** a service **270** is configured, targeted or intended to handle or process. In one embodiment, a user, such as the administrator of the appliance **200** configures the connection capacity **625** for the service **270**. In another embodiment, the appliance **200** determines the connection capacity **625** from the service **270** or server **106** providing the service **270**. For example, the appliance **200** may transmit a request to the server **106** or service **270** for its connection capacity, and in response, the server **106** transmits to the appliance a predetermined number of active connections it may handle.

Each of the connection capacities **625**A-**625**N may comprise any combination of a same or different connection capacity **625** as another capacity. In one embodiment, the connection capacity **625**A for a first server **270**A is different than the connection capacity **625**B of a second server **270**B. In some embodiments, the connection capacity **625**A for a first service **270**A is the same as the connection capacity **625**B for a second service **270**B. In another embodiment, the connection capacity **625**A of a service **270**A may be set to a value below the service's actual connection capacity. In other embodiments, the connection capacity **625**A of a service **270**A may be set to a value above the service's actual connection capacity. In some embodiments, the connection capacities may represent a connection-based weighting of each of the services **270**A-**270**N in a first set or second set of a plurality of services.

The dynamic maximum connection threshold **1020**A-**620**N (generally **620**) comprises a predetermined number identifying a maximum number of active transport layer connections the vServer **275** is configured, designed or otherwise intended to process, handle or have active. In one embodiment, a user, such as an administrator of the appliance **200**, configures the dynamic maximum connection threshold **1020**. In another embodiment, the appliance **200** sets the dynamic maximum connection threshold **1020** to a default value of the sum of the configured connection capacity for each of the services **270**A-**270**N managed by the vServer **275**.

The appliance **200** may adjust the dynamic maximum connection threshold **1020** in response to events corresponding to a vServer **250** and to one or more services **270**. The appliance **200** may monitor the services **270** using one or more monitoring agents **420**. In one embodiment, the appliance may adjust the dynamic maximum connection threshold in response to a monitoring agent **420** reporting a service **270** as unavailable. If a service **270** with a given connection capacity is reported as unavailable, the appliance may subtract the service's **270** connection capacity from the dynamic maximum connection threshold **1020** of the vServer providing access to that service **270**. Further, if the service **270** previously reported as unavailable is then reported as available, the appliance **200** may then add back the connection capacity for that service **270** to the dynamic maximum connection threshold **1020**.

The monitoring agents may monitor any aspect of a service **270**, and may use any technique to determine whether a given service is available. In one embodiment, a monitor may measure the response time of a service **270** and report the service as unavailable if the response time exceeds a given threshold. In another embodiment, a monitor may measure the response time of a service **270** and report the service as unavailable if the response time exceeds a determined average response time for the service **270**. In still another embodiment, a monitor may measure the response time of a service **270** and report the service **270** as unavailable if the response time exceeds a given deviation from a determined average response time for the service.

Although the technique of dynamically adjusted maximum connection threshold **1020** is generally discussed in view of transport layer connections and connection requests, the appliance may perform this technique for any type and form of transport layer protocol or application layer protocol carried via the transport layer. In one embodiment, the appliance **200** may perform dynamic connection spillover among vServers **275**A-**275**N using a dynamically adjusted maximum connection threshold **1020** for Secure Socket Layer (SSL) or Transport Layer Security (TLS) connections and connection requests.

Referring now to FIG. **7**, steps of an embodiment of a method for practicing a technique of dynamical spillover management is depicted. In brief overview, the method comprises establishing, on an appliance, a first virtual server which directs transport layer connection requests from a plurality of clients to a first plurality of services (step **705**); establishing, via the appliance, a predetermined threshold identifying a maximum active transport layer connection capacity for the first virtual server, the predetermined threshold comprising a sum of a predetermined connection capacity for each of the plurality of services (step **710**); monitoring, by the appliance, a status for each of the plurality of services (step **715**); and adjusting, by the appliance, the predetermined threshold to comprise the sum of the predetermined connection capacity for each of the plurality of services having a status of available (step **720**). The appliance may then receive a transport layer connection request (step **725**); determine that a number of active connections to the first virtual server exceeds the predetermined threshold (step **730**). The appliance may then determine to provide the request to a second virtual server (step **740**).

Still referring to FIG. **7**, now in greater detail, an appliance establishes a first virtual server which directs transport layer connection requests from a plurality of clients to a first plurality of services (step **705**). This virtual server may comprise any virtual server capable of providing access to one or more services **270**. In one embodiment, the virtual server may comprise a vServer **275**. In one embodiment, the appliance may establish the virtual server upon startup of the appliance. In another embodiment, the appliance may establish the virtual server in response to a previously established virtual server exceeding maximum connection threshold. In one embodiment, the appliance may establish a plurality of virtual servers.

In the embodiment shown, the appliance may then establish a dynamic maximum connection threshold **1020** for the first virtual server (step **710**). In some embodiments, the threshold comprises a sum of a predetermined connection capacity for each of the plurality of services. In one embodiment, the threshold **1020** may be initially configured by a user or administrator of the appliance. In another embodiment, the threshold **1020** may be initially determined by the appliance by polling one or more services **270**.

In the embodiment shown, the appliance may then monitor a status for each of the plurality of services (step **715**). The appliance may monitor a status for each of the services **270** using any means. In one embodiment, the appliance may use a monitoring agent **420**. In another embodiment, the appliance may use a plurality of monitoring agents **420**. In one embodiment, the appliance may monitor the status for each of the services at predetermined time intervals, for example once every 0.01, 0.1, 0.2, 0.5, or 1 seconds. In another embodiment, the appliance may monitor the status for each of the services **270** asynchronously.

In the embodiment shown, the appliance may then adjust the predetermined threshold to comprise the sum of the predetermined connection capacity for each of the plurality of services having a status of available (step **720**). For example, if a service **270** with a given connection capacity is reported as unavailable, the appliance may subtract the service's **270** connection capacity from the dynamic maximum connection threshold **1020** of the vServer providing access to that service **270**. Further, if a service **270** previously reported as unavailable is then reported as available, the appliance **200** may then add back the connection capacity for that service **270** to the dynamic maximum connection threshold **1020**.

In the embodiment shown, the appliance may then receive a transport layer connection request (step **725**). The transport layer request may comprise any request to connect to a service **270**. The transport layer request may be received from any computing device including a client **102**, server **106**, or a second appliance **200**. In one embodiment, the request may identify a type of service **270**. For example, the transport layer request may comprise a request for HTTP service. Or, for example, the transport layer request may comprise a request for UDP service.

In the embodiment shown, the appliance may then determine whether the dynamic maximum connection threshold **1020** of the first virtual server has been exceeded. The appliance may compare the current connection load for the first virtual server with the current value of the dynamic maximum connection threshold for the first virtual server. In one embodiment, the first virtual server may comprise a primary or default virtual server. In another embodiment, the first virtual server may comprise a primary or default virtual server for a particular type of service. If the dynamic maximum connection threshold **1020** of the first virtual server has not been exceeded, the appliance may provide the connection request to the first virtual server (step **735**).

If the dynamic maximum connection threshold **1020** of the first virtual server has been exceeded, the appliance may establish, in response to the threshold being exceeded, a second virtual server (step **740**). In other embodiments, a second virtual server may already have been established prior to some or any of the steps shown. The second virtual server may provide access to a second plurality of services **270**. In one embodiment, one or more of the second plurality of services **270** may comprise the same type of service **270** as one or more of the first plurality of services. The appliance may then establish and subsequently adjust a dynamic maximum connection threshold **1020** corresponding to the second virtual server. The appliance may then provide the connection request to the second virtual server **200** (step **755**).

In other embodiments, a second virtual server may already have been established prior to some or any of the steps shown. The second virtual server may provide access to a second plurality of services **270**. In one embodiment, one or more of the second plurality of services **270** may comprise the same type of service **270** as one or more of the first plurality of services. The appliance may then provide the connection request to the second virtual server **200** (step **755**). The appliance may then establish and subsequently adjust a dynamic maximum connection threshold **1020** corresponding to the second virtual server.

In still other embodiments, if the dynamic maximum connection threshold **1020** of the first virtual server has been exceeded, the appliance may, in response to the threshold being exceeded, redirect the client making the request to another resource. In one embodiment, the appliance may transmit a URL to the client comprising the address of a server **106** or service **270** such that the client may bypass the appliance **200** and access the server **106** or service **270** directly. In one embodiment, the appliance may transmit a URL to the client comprising the address of a second appliance **200**. In still another embodiment, the appliance **200** may redirect the client request to a second appliance based on a dynamically determined connection capacity for the second appliance.

The appliance **200** may then determine whether the client making the connection request has a previously existing connection with either the first or a second virtual server (step **750**). In some embodiments, an appliance may assign a priority to providing connection requests from a client to virtual servers that have previously serviced or are currently servicing connections from the client. For example, if a connection request is received from a client, and the client has a currently existing connection with a first virtual server, the appliance **200** may provide the connection request to the first virtual server even if the first virtual server is above its dynamic maximum connection threshold. Or, for example, if a client has a previous connection via a backup virtual server, and the primary virtual server subsequently becomes available again, the appliance **200** may still provide a subsequent connection request from the client to the backup virtual server. In one embodiment, a connection management mechanism **610**, or other appliance component may track previously established or current connections so that incoming connection requests from a client can be provided to a virtual server having previously serviced connections from the client.

F. Systems and Methods for Dynamic Spillover Based on Bandwidth

Referring now to FIGS. **8**A and **8**B, systems and methods for dynamically managing connection spillover from a first virtual server to a second virtual server based on bandwidth are depicted. The appliance may establish or a user may configure a bandwidth threshold for one or more virtual servers managing one or more services. The appliance monitors the bandwidth used by a virtual server. In response to detecting the bandwidth reaching or exceeding the bandwidth threshold, the appliance dynamically directs client requests to another virtual server. The bandwidth threshold may be adjusted to take into account bandwidth capacity, response times, virtual server performance or performance of the server. The appliance manages virtual servers based on the bandwidth usage to maintain performance of the virtual servers and the services managed by the virtual servers at a desired level or within a predetermined performance range.

Referring now to FIG. **8**A, an embodiment of an appliance for providing dynamic virtual server spillover management based on bandwidth is depicted. In brief overview, the appliance **200** establishes a first vServer **275**A to manage access by a plurality of clients **102***a*-**102***n* to one or more services **270**A-**270**N of a first set of servers **106**A-**106**N. The appliance **200** includes a connection management mechanism **610** for managing and balancing requests from clients **102***a*-**102***n* to one or more set of services **270**A-**270**N via one or more vServers **275**A-**275**N. The appliance **200** establishes for a first vServer **275**A a bandwidth threshold **820**A, which may be specified by a user. The appliance may establish a second vServer **275**N with a second bandwidth threshold **820**B.

Via monitoring agents **420**A-**420**N, the appliance monitors the operational status of each of the services **270**A-**270**N. The monitoring agents **420** may include a bandwidth detector **802** for measuring the bandwidth used by a virtual server **275**. The bandwidth detector **802** may at predetermined frequencies or time frames determine a measured bandwidth **825**A for a first vServer **275**A. The bandwidth detector **802** may also determine a measured bandwidth **825**B for the second vServer **275**N.

If the measured bandwidth for the first vServer **275**A is determined to have reached or exceeded the bandwidth threshold **820**A, the connection manager **610** of the appliance may determine to direct client requests to the second vServer **275**N. For example, a user may configure a bandwidth threshold of 5 Mbytes per second. If the bandwidth detector **920** determines the measured bandwidth **825** of the vServer **275** exceeds 5 Mbytes a second, the appliance **200** via the connection management mechanism **610** may switch client requests to the second vServer **275**N.

The bandwidth detector **802** includes or provides logic, business rules, functions or operations for determining an availability, idleness, throughput or utilization of network bandwidth for one or more virtual servers **275**. The bandwidth detector **802** may include software, hardware or any combination of software and hardware. The bandwidth detector **802** may comprise an application, program, script, library, process, service, driver, task, thread or any type and form of executable instructions.

In some embodiments, the bandwidth detector **802** determines a number of bytes transferred by the vServer **275** for the measured bandwidth **825**. The bandwidth detector **802** determines the number of transferred bytes over a time period, such as every second or bytes transferred per second. In one embodiment, the bandwidth detector **802** determines an average number of bytes transferred per the time period, such as per second. In some embodiments, the bandwidth detector **802** measures the number of bytes transmitted by the vServer **275**. In other embodiments, the bandwidth detector **802** measures the number of bytes received by the vServer **275**. In one embodiment, the bandwidth detector **802** measures the number of bytes received and transmitted by the vServer **275**. In yet another embodiment, the bandwidth detector **802** measures the number of bytes transmitted by the one or more services **270** to the vServer **275**. In other embodiments, the bandwidth detector **802** measures the number of bytes transmitted by one or more clients **102** to the vServer **275**. In other embodiments, the bandwidth detector **802** measures the bandwidth **825** for a vServer **275** based on the number of packets on a queue waiting to be transmitted. In some embodiments, the bandwidth detector **802** determines bandwidth usage via the transition of a queue of network packets from empty to non-empty and vice-versa.

In one embodiment, the bandwidth detector **802** determines the measured bandwidth **825** in relation to round-trip times between a virtual server and a service **270** or server **106**. In one embodiment, the bandwidth detector **802** measures round-trip times between a virtual server and a client **106**. In another embodiment, the bandwidth detector **802** measures round-trip times between a client and server via the virtual server **275**. The bandwidth detector **802** may use any type and form of round-trip time computation or calculation to measure bandwidth **825**. For example, the bandwidth detector **802** may use the following type of bandwidth measurement:

Bandwidth=Factor*MTU/(Round Trip Times*sqrt (Packet Loss)), where the factor may be for example 1.3

As illustrated by the above equation, bandwidth may be determined based on packet loss, round trip times and/or packet size adjusted by a predetermined factor. Although a measurement of bandwidth using the above equation is described, other derivatives of this request using any combination of factors, maximum transmission unit (MTU), round trip times and packet loss may be used.

The bandwidth threshold **820** for a vServer **275** may be specified as a number, such as a real or integer. In one embodiment, the bandwidth threshold **820** may be expressed in units of number of bytes per a unit of time. In some embodiments, the bandwidth threshold **820** may be specified as a percentage. For example, the bandwidth threshold **820** may represent a percentage of bandwidth used by the vServer **275**. In another example, the bandwidth threshold **820** may represent a percentage of bandwidth available to the vServer **275**.

In some embodiments, the bandwidth threshold **820** may indicate a direction for measuring the bandwidth **825** of a vServer **275**. In one embodiment, the bandwidth threshold **820** identified the measurement is bi-directional. For example, the bandwidth threshold **820** may indicate to measure bandwidth **825** of bytes transmitted by the vServer **275** to the service and received from the service. In another example, the bandwidth threshold **820** may indicate to measure bandwidth **825** of the number of bytes sent from a client to the service via the vServer **275** and sent from the server to the client via the vServer **275**. In other embodiments, the bandwidth threshold **820** may indicate to measure bandwidth **825** in one direction, such as any of the following directions: from the vServer to the service, from the service to the vServer, from the vServer to the client.

As discussed above in connection with FIG. **8**A, the connection management mechanism **610**, also referred to as a connection manager or a virtual server switch, comprises software, hardware, or any combination of software and hardware having logic, functions or operations for receiving and managing connection requests and communications from one or more clients **102**A-**102**N. In one embodiment, the connection management mechanism **610** receives or intercepts transport layer connection requests and communications between the clients **102**A-**102**N and one or more services **270**A-**270**N. The connection management mechanism **610** may include an application, program, service, process, task, thread or any type and form of executable instructions. In response to receiving a client communication, the connection management mechanism **610** identifies, determines or selects a vServer **275** for processing a received communication from a client **102**.

The connection manager **610** may operate responsive to the load monitor **420** and/or the bandwidth detector **802**. The load monitor **420** may monitor the measured bandwidth **825**. In some embodiments, the load monitor **420** and/or bandwidth detector **802** measures the bandwidth on a predetermined frequency. In one embodiment, the load monitor **420** and/or bandwidth detector **802** measures the bandwidth responsive to any events, such as receipt of a network packet. In other embodiments, the load monitor **420** and/or bandwidth detector **802** may determine whether or not if the measured bandwidth **825** is greater than the bandwidth threshold **820**.

If the connection manager **610** determines from the load monitor **420** and/or bandwidth detector **802** that the measured bandwidth **825** of a first vServer **275**A exceeds the bandwidth threshold **820**, the connection manager **610** directs client requests for the services managed by the first vServer **275**A to a second vServer **275***n*. The second vServer **275***n* may be configured or established as backup server to the first vServer **275**A. For example, the first vServer **275**A may be designated a primary vServer **275**A and the second vServer **275**N as backup vServer **275**N. In another embodiment, the second vServer **275**N may be another virtual server—primary, redundant, or otherwise—for managing the services **270**A-**270**N. In yet another embodiment, the second vServer **275**N is configures or designated as the spillover virtual server for the first vServer **275**A. In some cases, the second vServer **275**N is established upon determining the first vServer **275275**A exceeds the bandwidth threshold **820**. In other cases, the vServer **275**N is already operating or executing on the appliance **200**.

In some embodiments, the connection manager **270** directs new client connection requests to the second vServer **275**. In one embodiment, if the request is from a connection already established with the first vServer **275**A, the connection manager **610** may direct the request to the first vServer **275**A even if the bandwidth threshold **820** is exceeded. This may be referred to as connection or session persistence. In another embodiment, the connection manager **610** directs any client requests to the second vServer **275**, for example, even a request of a previously established connection.

In one embodiment, the connection manager **610** directs client requests to the second vServer **275**N while the first vServer **275** has a measured bandwidth **825** greater than the bandwidth threshold **820**. In another embodiment, the connection manager **610** directs clients requests back to the first vServer upon determining that the measured bandwidth **825** of the first vServer **275** has fallen within the bandwidth threshold **820**. In some embodiment, the connection manager **610** determines which of the first vServer **275**A and the second vServer **275**N has the lowest bandwidth usage or is the least nearest to the corresponding bandwidth threshold **820** and directs the client requests to the determined vServer. In other embodiments and in the case of multiple vServers **275**A-**275**N exceeding a bandwidth threshold **820**, the connection manager **610** determines which vServer **275**A-**275**N exceeds its corresponding threshold **820** the least and directs the client requests to the determined vServer.

In some embodiments, the appliance **200** via a load monitor **420** and/or bandwidth detector **802** measures and monitors the bandwidth of the second virtual server **275**N. The second vServer **275**N may have the same bandwidth threshold **820** or a different bandwidth threshold **820** as the first vServer **275**A. If the connection manager **610** determines from the load monitor **420** and/or bandwidth detector **802** that the measured bandwidth **825**N of the second vServer **275**N exceeds the bandwidth threshold **820**, the connection manager **610** directs client requests for the services managed by the second vServer **275**A to another vServer **275**N, such as the first vServer **275**A or a third vServer **275**B. The second vServer **275**N may have a third vServer **275**B designated as backup virtual server or a spillover virtual server. The bandwidth threshold management techniques described herein may be used for a chain or plurality of virtual servers and spillover virtual servers, each with a bandwidth threshold and designated backup or spillover virtual server.

The appliance via the connection manager directs client requests to the primary vServer **275** or any backup or spillover vServer **275** based on measured bandwidth **825** in view of the established bandwidth thresholds **820**. The appliance **200** may dynamically adjust any bandwidth threshold **820** for any vServer **275** based on any performance or operational characteristics of the appliance, vServer, bandwidth, network connection, client or server. For example, the load monitor and/or bandwidth detector may measure the bandwidth of the vServer or the network connection based on round trip times, packet loss and/or MTU. In one embodiment, the appliance may determine that the established bandwidth threshold **820** is set relatively low in comparison to the measured bandwidth **825** and determines to dynamically increase the bandwidth threshold **820**. For example, the appliance may adjust to the bandwidth threshold **820** within a certain percentage or threshold of the measured bandwidth. In another embodiment, the appliance may determine that the established bandwidth threshold **820** is set relatively high in comparison to the measured bandwidth **825** and determines to dynamically decrease the bandwidth threshold **820**.

In one case, the appliance **200** dynamically sets or establishes a bandwidth threshold **820** by measuring bandwidth **825** of a vServer **275** for a predetermined time period. For example, upon startup of a vServer **275**, the bandwidth detector **802** may measure bandwidth for a predetermined or configured time period, and then based on an average, peak or range of bandwidth measurements set the bandwidth threshold **820**. In yet other examples, the appliance **200** may dynamically adjust a bandwidth threshold **820** based on running additional vServers **275** or stopping, shutting down or other removing a vServer **275**. In another case, the appliance **200** may dynamically adjust a bandwidth threshold **820** based on adding or removing services **270**A-**270***n* managed by a vServer **275**. In still other embodiments, the appliance **200** may dynamically adjust the bandwidth threshold **820** of a vServer **275** based on information and feedback from a monitoring agent **197** and/or monitoring service **198**. In still other embodiments, the appliance **200** may dynamically adjust bandwidth thresholds **820** based on one or more policies of a policy engine **195**.

In some embodiment, the appliance **200** excludes a vServer **275** from a load computation or determination, or otherwise a load balancing decision if the bandwidth used **825** by the vServer **275** exceeds the bandwidth threshold **820**. In these embodiments, this may be done so that the other vServer **275**A-**275**N which carry the load for the excluded vServer

275 do not also become overloaded. In other embodiments, the appliance **200** adjusts a weight used for the vServer **275** upon detecting the vServer's bandwidth **825** exceeds the bandwidth threshold **820**. For example, the weight of the vServer **275** may be adjusted to minimize the impact to the other vServer **275A-275N** for not having the vServer **275** available to also service requests.

Referring now to FIG. **8B**, an embodiment of steps of a method for practicing dynamic virtual server spillover management based on bandwidth is depicted. In brief overview, at step **805**, the appliance establishes a first virtual server **275A** which directs requests from a plurality of clients to a plurality of services. At step **810**, the appliance establishes a bandwidth threshold for the first virtual server. At step **815**, the appliance monitors a status for each of the plurality of services. At step **820**, the appliance measures and monitors the bandwidth **825** used by the first vServer **275**. At step **825**, the appliance receives a client request. At step **830**, the appliance determines whether or not the bandwidth threshold for the first vServer **275A** has been exceeded. If not, at step **835**, the appliance directs the client request to the first vServer **275A**. If the threshold has been exceeded, the appliance at step **840** determines whether or not to establish or use a second vServer **275N** or provide a redirect URL to the client **102**. In one case, at step **845**, the client is redirected to the service and bypasses the first vServer **275A**. At step **850**, the appliance may determine if the client is persistent with the first vServer **275A** or the second vServer **275N**. If the client is sticky to the first vServer **275A**, the appliance may direct the request to the first vServer **275A** at step **835**. Otherwise, the appliance spills over to an established second vServer **275N** at step **855**. The method may continue at step **810** to monitor and perform spillover management for the second vServer **275N**.

In further detail, at step **805**, an appliance establishes a first virtual server **275** which manages connections and direct requests from a plurality of clients to a first plurality of services **270**. In one embodiment, the appliance may establish the virtual server upon startup of the appliance. In another embodiment, the appliance may establish the virtual server in response to a previously established virtual server exceeding maximum connection threshold. In one embodiment, the appliance may establish a plurality of virtual servers. In some embodiments, a user configures and starts the first vServer **275**. In other embodiments, the first vServer is configured, established or designed by the appliance or a user as a primary virtual server.

At step **810**, the appliance may establish or otherwise provide a bandwidth threshold **820** for the first vServer **275**. In one embodiment, the bandwidth threshold **820** may be initially configured by a user or administrator of the appliance. In another embodiment, the bandwidth threshold **820** may be initially determined by the appliance by monitoring the bandwidth used by the vServer **275** or by polling one or more services **270**. In some embodiments, the appliance **200** may use a default or predetermined bandwidth threshold **820**. For example, the appliance may use a predetermined bandwidth threshold **820** associated with or based on the type of service **270**.

At step **815**, the appliance may monitor a status for each of the services **270** using any means. In one embodiment, the appliance may use a monitoring agent **420**. In another embodiment, the appliance may use a plurality of monitoring agents **420**. In one embodiment, the appliance may monitor the status for each of the services at predetermined time intervals, for example once every 0.01, 0.1, 0.2, 0.5, or 1 seconds. In another embodiment, the appliance may monitor the status for each of the services **270** asynchronously or based on any events.

At step **820**, the appliance measures and monitors the bandwidth used in association with the first vServer **275A**. The load monitor **420** and/or bandwidth detector **802** may compute, determine or otherwise make bandwidth measurements **925**. In one embodiment, the appliance determines the measured bandwidth **825** of a vServer **275** on a predetermined frequency. In another embodiment, the appliance determines the measured bandwidth **825** of a vServer **275** triggered by an event. In one case, the appliance determines the measured bandwidth **825** of a vServer **275** at the request of a user. In some embodiments, the appliance **200** measures bandwidth based on a number of bytes transferred to and/or from a vServer **275**. In other embodiments, the appliance **200** measures bandwidth based on round trip times of communication to and/or from a vServer **275**. In some embodiments, the appliance may dynamically adjust the bandwidth threshold **820** based on bandwidth measurements. In other embodiments, the appliance may dynamically adjust the bandwidth threshold **820** based on performance and/or operational characteristics of the appliance, the vServer **275**, the network connection, and/or the service **270**.

At step **825**, the appliance may receive a client request. In one embodiment, the appliance intercepts the client request as a transparent interception device. In another embodiment, the client transmits the request to the appliance as a proxy. In some embodiments, the appliance receives a client request to open or establish a transport layer connection. In other embodiments, the appliances receive a client request to access a service via a previously established transport layer connection. The transport layer request may be received from any computing device including a client **102**, server **106**, or a second appliance **200**. In one embodiment, the request may identify a type of service **270**. For example, the transport layer request may comprise a request for HTTP service. Or, for example, the transport layer request may comprise a request for UDP service.

At step **830** the appliance may determine whether the measured bandwidth **825** for a vServer **275** has reached or exceeded the bandwidth threshold **820**. The appliance may compare the current measured bandwidth **825** for the first virtual server with the current value of the bandwidth threshold **820** for the first virtual server. In other embodiments, the load monitor **420** and/or bandwidth detector **802** may have already determined the bandwidth threshold **925** for the vServer **275** has been reached or exceeded. In another embodiment, the appliance **200** may determine if the bandwidth threshold **825** has been reached or exceeded responsive to receiving the client request. If the bandwidth threshold **820** of the first virtual server has not been exceeded, the appliance may provide the client request to the first virtual server at step **835**.

If the appliance determines the bandwidth threshold **820** of the first virtual server has been exceeded, the appliance may establish, use or otherwise spillover to a second virtual server **275N** at step **840**. In other embodiments, a second virtual server **275N** may already have been established prior to some or any of the steps shown. In another embodiment, the second virtual server **275N** may be established responsive to determining the bandwidth threshold **820** has been exceeded. The second virtual server may provide access to a second plurality of services **270**. In one embodiment, one or more of the second plurality of services **270** may comprise the same type of service **270** as one or more of the first plurality of services. The appliance may then establish and/or adjust a bandwidth threshold **820** for the second virtual server. The appliance may provide the client request to the second virtual server **275** at step **855**.

In other embodiments, if the bandwidth threshold **820** of the first virtual server has been exceeded, the appliance may redirect the client making the request to another resource. In one embodiment, the appliance may transmit a URL to the client comprising the address of a server **106** or service **270** such that the client may bypass the appliance **200** and access the server **106** or service **270** directly. In one embodiment, the appliance may transmit a URL to the client comprising the address of a second appliance **200**. In still another embodiment, the appliance **200** may redirect the client request to a second appliance.

At step **850**, the appliance **200** may determine whether the client making the request has a previously existing connection or session with either the first or a second virtual server. In some embodiments, an appliance may assign a priority to providing requests from a client to virtual servers that have previously serviced or are currently servicing connections or session from the client. For example, if a request is received from a client, and the client has a currently existing connection with a first virtual server, the appliance **200** may provide the request to the first virtual server even if the first virtual server has reached or exceeded the bandwidth threshold. Or, for example, if a client has a previous connection via a backup virtual server, and the primary virtual server subsequently falls below the bandwidth threshold **820**, the appliance **200** may still provide a subsequent request from the client to the backup virtual server. In one embodiment, a connection management mechanism **610**, or other appliance component may track previously established or current connections or session so that incoming requests from a client can be provided to a virtual server having previously serviced the connection or session from the client.

At step **855**, the appliance **200** may dynamically manage virtual spillover based on bandwidth by directing or providing the client request to the spillover or second vServer **275**N. In some embodiments, the appliance determines the second vServer **275** is busy, unavailable or has exceeded its bandwidth threshold or another threshold. In response, the appliance may redirect the client at step **840** or provide the client request to a third vServer **275**B or another appliance **200'**. In some embodiments, the appliance has a plurality of vServers **275**A-**275**N managing the services **270** and determines which vServer to direct the client request based on comparison of each vServer's measured bandwidth and/or bandwidth threshold. In one case, the appliance provides the client request to one of a plurality of backup or spillover vServers based on the least measured bandwidth. In another case, the appliance provides the client request to the vServer with the greatest difference between the measured bandwidth and the bandwidth threshold.

Although an embodiment of method **800** is generally described above in regards to measuring and monitoring bandwidth of a first vServer and spilling over to a second vServer, any steps of the method may be performed for the second vServer and a spillover server for the second vServer, and for a third vServer, and so on. An embodiment of method **800** or any steps thereof may be practiced for a plurality of virtual servers, such as a set of primary vServer managing the same or different services. Another embodiment of method **800** or any steps thereof may be practiced for a chain of spillover virtual servers, so that a second vServer spills over into a third vServer based on bandwidth and so on.

Furthermore, any of the systems and method discussed herein may be practiced in combination. For example, the techniques of dynamic connection spillover management described in conjunction with FIGS. **6** and **7** may be practiced with the bandwidth based spillover management described in conjunction with FIGS. **8**A and **8**B. In some embodiment, the appliance may establish, monitor and manage spillover of virtual servers based on multiple thresholds. For example, the appliance may use both connection based thresholds and bandwidth based thresholds to determine to spillover a client request from one virtual server to another. In one embodiment, the appliance may spillover from one virtual server to another virtual server when both thresholds are reached or exceeded. In another embodiment, the appliance may spillover from one virtual server to another virtual server when either of the thresholds are reached or exceeded.

In some embodiments, the techniques of bandwidth based virtual server switching and spillover management described above may be combined with the content switching functionality and policies of the appliance to provide bandwidth management of a virtual server on an object basis. The appliance may be configured to have a set of one or more virtual servers to manage requests and response of predetermined object types. A first virtual server may be configured to provide requests to a second virtual server if the request identifies an object matching a pattern, such as a pattern of URL or file extension. For example, the first virtual server may direct the second virtual server to handle all image file requests with the extension of *.jpg, or *.gif. For these object types, the second virtual server manages requests and response of a plurality of services. The second virtual server may also be under bandwidth management by the appliance and have a bandwidth threshold. The appliance via one or more monitoring agents monitor the second virtual server to determine if the bandwidth used by the second virtual server in handling the requests for these object types is exceeded. If the threshold is exceeded, the appliance or first virtual server may spillover handling of the requests of these object types to another virtual server. Or in some cases, the appliance may provide a redirect URL to the client or redirect the client's request to another appliance, a server or to the service.

Referring now to FIG. **9**A, an embodiment of an appliance **200** for practicing a technique of object based bandwidth switching and spillover management is depicted. In brief overview, the appliance **200** establishes a first vServer **275**A to manage access by a plurality of clients **102***a*-**102***n* to one or more virtual servers **275**A'-**275**N'which in turn manager access to one or more services **270**A-**270**N of a first set of servers **106**A-**106**N. The appliance **200** includes a connection management mechanism **610** for managing and balancing requests from clients **102***a*-**102***n* to the vServers. A first vServer **275**A may be configured via a policy engine **935** and/or via content switching **284** to direct requests from clients to one or more vServer **275**A'-**275**N' based on the type of object **902**A or objects identified via the request. In some cases, a policy of a policy engine provides logic or rules to determine which requests are forwarded by the first vServer **275** to one of the plurality of vServer **275**A'-**275**N'. For example, the first vServer **275** may direct all requests matching a pattern for a URL may be transmitted to a second vServer **275**A. Another vServer **275**N may be configured to direct client request matching another policy or object type **902**N to a second set of one or more vServers **275**A"-**275**N".

The appliance **200** establishes for any of the object handling vServers **275**A'-**275**N a bandwidth threshold **820**A. This bandwidth threshold may be established by the appliance or specified by the user. Via monitoring agents **420**A-**420**N, the appliance monitors the operational status of each of the object handling vServers **275**A'**275**N' and corresponding services **270**A-**270**N. For example, as previously discussed above, the monitoring agents **420** may use a bandwidth detector **802** to determine or measure bandwidth usage by a virtual server. If the measured bandwidth for a second vServer **275**A' is determined to have reached or exceeded the bandwidth threshold **820**A, the first virtual server **275**A and/or connection manager **610** of the appliance may determine to direct client requests to a spillover vServer **275**B which may handle requests for the same object type as the second vServer **275**A. For example, a user may configure a bandwidth threshold of 5 Mbytes per second for graphic image object types, such as files with a *.jpg extension. If the bandwidth detector **820** determines the measured bandwidth **825** of the vServer **275**A' exceeds 5 Mbytes a second, the appliance **200** may switch or spillover client requests to another vServer **275**N'.

In some embodiments, a virtual server **275** may be designed, constructed or configured to manage other virtual servers. In one embodiment, a virtual server **275**A-**275**N may be designed, constructed or configured to direct requests to other virtual servers based on any type and form of object type. In some embodiments, a vServer **275**A-**275**N comprises any of the functionality and capabilities of the content switching **284** functionality as described above in FIG. **2**B. In one embodiment, the vServer **275**A-**275**N includes logic, functions, rules or operations to identify an object or objects from any content of a request or network packet(s) thereof. In some embodiments, the vServer **275**A-**275**N identifies type of objects from URLs, or portions thereof. For example, the vServer **275**A-**275**N may identify an object type from a URL of request by matching a predetermined URL pattern to the request's URL. In other embodiments, the vServer **275**A-**275**N identifies types of objects from any file references, file names, file types or file extensions in the content of the request. In another embodiment, the vServer **275**A-**275**N identifies types of objects from a request via any headers of any protocol layer of the requests, such as HTTP headers in an application layer protocol portion of the request.

In still other embodiments, the vServer **275**A-**275**N identifies types of objects from any portion of any network packet(s) for a request. In one embodiment, the vServer **275**A-**275**N associates an internet protocol address and/or port with an object type. In these embodiments, the vServer **275**A-**1275**N identifies the object type from the source and/or destination of the network packet. In some embodiments, the vServer **275**A-**275**N identifies or associates an object type from any header fields of any protocol layer of a network packet. In other embodiments, the vServer **275**A-**275**N identifies or associates an object type from any option field of a header, such as TCP or IP option field. In another embodiment, the vServer **275**A-**275**N identifies an object type from any information encoded in a header or payload of a packet. In one embodiment, the vServer **275**A-**275**N identifies an object type by a type of protocol used for the request.

In other embodiments, a vServer **275**A is designed to determine which requests to forward or provide to other virtual servers responsive to a policy engine **238**. In some embodiments, the policy engine **238** includes one or more policies **1003** which identify rules for which the vServer **275**A-**275**N may direct client requests to one of the other vServers **275**A'-**275**N'. In one embodiment, the policy **903** identifies to a vServer **275**A-**275**N any portion of content of a network packet or of a request to associate with an object type or otherwise direct to a vServer **275**A'-**275**N. In another embodiment, the policy **903** identifies to a vServer **275**A-**275**N any portion of content of a network packet or of a request to direct to a predetermined set of one or more services **270**. In other embodiments, the policy **903** provides rules for matching any patterns of the rule to requests to associate with or identify an object type. For example, the policy **903** may identify a string pattern for a portion of a URL. In another example, the policy **903** may specify a pattern or rule for name of a file, or portion thereof. In further examples, the policy **903** may specify a pattern or rule for a file extensions. In still other cases, the policy **903** may specify a web page name with an object type. In another case, the policy **903** may specify a source and/or destination IP address and/or port with an object type. In one case, the policy **902** may specify a type of protocol to associate or identify an object type. The policy engine **238** and/or polices **1003** may specify any portion of a network packet, such as any data element of a header or payload, to use to identify an object type or otherwise indicate to a vServer **275**A-**275**N to provide requests to other vServer **275**A'**275**N' or services **270**.

In view of the various ways to identify types of objects, an object type **902** may comprise any type and form of categorization, classification, grouping or identification. An object type may be an identification of an object as a certain type or belong to a group or classification. Any data or information included in, referenced by or associated with a client request may used to identify an object, or type thereof. An object type may also be referred to or considered an object identifier. In one embodiment, an object type **902**A-**902**N may be based on groups of one or more object types. In other embodiments, an object type **902**A-**1002**N may be granular and based on a specific name, reference or instance of an object. In some embodiments, the object type comprises types of files by name, content, or extension. For example, a first object type **902**A may includes objects having a first file name extension, and a second object type **902**N may include objects having a second file name extension. In another example, an object type **902**A may include a group of objects, such as any object having one of a plurality of file name extensions. In yet further examples, the object type **902** may identify any type and form of media, such as voice, audio, data or any combination.

In other embodiments, an object type **902** is based on a pattern for a URL. In another embodiment, an object type **902** is based on a destination portion of a URL. In some embodiments, the object type **902** may be based on a domain or server identified by a URL. In one embodiment, the object type **902** may include URLs that identify a specified web page. In some embodiments, an object type **902** may include a set or group of one or more URL patterns, or portions of URLs. In yet other embodiments, an object type **902** is based on a source and/or destination of the request. In one embodiment, the object type **902** is based on the type of protocol used by the request. In other embodiments, the object type **902** is based on any information of a header or payload of a packet(s) for the request.

In still other embodiments, a user may configure or identify object types **902**A-**1002**N in any desired combination, arrangement or manner. In one embodiment, a user may specify an object type **902** to be any URL pattern. In another embodiment, a user may specify an object type **902** to be any pattern for a resource or file identified in the request. In some embodiments, the user may specify any IP address and/or port to be used to identify an object type. In other embodiments, the user may specify any portion of a network packet, such as any header field or data in a payload, as identifying an object type **902**. In still further embodiments, a user may specify any matching portion of a request to be associated with an object type.

As illustrated in FIG. **9**A, multiple vServers **275**A-N may be configured, designed or constructed to direct client requests based on a multiple object types **902**A-**1002**N to a plurality of vServers **275**A'-**275**N' and **275**A"-**275**N". A first vServer **275**A may be configured to forward requests corresponding to a first object type to one or more vServers **275**A-**275**N, which manage one or more services **270**A-**270**N. A second vServer **275**N may be configured to forward requests corresponding to a second object type **902**N to a second set of one or more vServers **275**A'-**275**N', which manage one or more services **270**A'-**270**N'. For example, the first vServer **275**A may direct requests corresponding to graphical image related object types to a second vServer **275**A'. The second vServer **275**N may direct requests corresponding to predetermined URL patterns to a third vServer **275**A". In some cases, the second vServer **275**N may direct request corresponding to the object types handled by the first vServer **275**A to the second set of vServers **275**A'-**275**N'.

The appliance **200** may have a plurality of a first set of vServers **275**A-**275**N directing requests to a plurality of other vServers **275**A'-**275**N' and **275**A"-**275**N" based on a multitude of object types **902**A-**902**N. Object types **902**A-**902**N or policies thereof may be configured by a user to have a wide range of different types **902** from broad groupings to very granular object identifiers. For example, a first vServer **275**A may directs requests corresponding to a more broad classification of object types **902**, that are identifies as an HTTP object. In another example, a second vServer **275**N may directs requests corresponding to a more narrow identification of an object type, such a file by a specific name or a specific URL, or portion of a URL.

Referring now to FIG. **9**B, an embodiment of steps of a method for practicing an object and bandwidth based virtual spillover management and switching technique is depicted. In brief overview, at step **905**, the appliance establishes a first virtual server **275**A which directs requests from a plurality of clients corresponding to an object type **902** to one or more virtual servers **275**A'**275**N, such as a second virtual server **275**A'. At step **910**, the appliance establishes a bandwidth threshold for the second virtual server. At step **915**, the appliance monitors a status for each of the plurality of virtual servers, and corresponding to services. At step **920**, the appliance measures and monitors the bandwidth **825** used by the second vServer **275**A'. At step **925**, the appliance receives a client request. At step **930**, the appliance determines whether or not the bandwidth threshold for the second vServer **275**A' has been exceeded. If not, at step **935**, the appliance directs the client request to the second vServer **275**A'. If the threshold has been exceeded, the appliance at step **940** determines whether or not to establish or use a third vServer **275**N' or provide a redirect URL to the client **102**. In one case, at step **945**, the client is redirected to the service and bypasses the second vServer **275**A'. At step **950**, the appliance may determine if the client is persistent with the second vServer **275**A'. If the client is sticky or persistent to the second vServer **275**A, the appliance may direct the request to the second vServer **275**A' at step **935**. Otherwise, the appliance spills over to an established third vServer **275**N' at step **955**. The method may continue at step **910** to monitor and perform object based spillover management for the third vServer **275**N.

In further detail, at step **905**, an appliance establishes a first virtual server **275**A which manages connections and direct requests from a plurality of clients to a first set of one or more vServers **275**A'-**275**N'. The first set of one or more vServers **275**A'-**275**N' may manage, such as load balance, one or more services **270**. The first vServer **275**A may be configured to direct request identifying a first object type **902**A to a first set of one or more vServers **275**A'-**275**N', such as a second vServer **275**A'. In some embodiments, the first vServer **275**A determines or identifies object types from a request responsive to one or more policies **1003** of a policy engine **238**. In another embodiment, the first vServer **275**N determines which vServer **275**A'-**275**N' to direct the request responsive to a policy **903** and/or the policy engine **238**. In one embodiment, the appliance may establish a plurality of virtual servers **275**A-**275**N, each vServer **275**A-**275**N direct client requests based on a different object type or the same object type.

At step **910**, the appliance may establish or otherwise provide a bandwidth threshold **820** for any of the object handling vServers, such as the second vServer **275**A'. In one embodiment, the bandwidth threshold **820** may be initially configured by a user or administrator of the appliance. In another embodiment, the bandwidth threshold **820** may be initially determined by the appliance by monitoring the bandwidth used by the vServer **275** or by polling one or more services **270**. In some embodiments, the appliance **200** may use a default or predetermined bandwidth threshold **820**. For example, the appliance may use a predetermined bandwidth threshold **820** associated with or based on the type of service **270**. In other embodiments, the bandwidth thresholds **920** may be established by the appliance or user based on the object type. In one case, a vServer **275**A' may be configured to have a bandwidth threshold **820**A for a first object type **902** and another vServer **275**N' may be configured with a bandwidth threshold **820**N having a different threshold value than bandwidth threshold **820**A. For example, a vServer **275**A' processing requests for media content, such as video, audio may be designated with a larger bandwidth threshold **820**A than a vServer **275**B' handlings requests for smaller files or web pages.

At step **915**, the appliance may monitor a status of any of the vServers and any vServers or services **270** under management. In one embodiment, the appliance may use a monitoring agent **420**. In another embodiment, the appliance may use a plurality of monitoring agents **420**A-**420**N. In one embodiment, the appliance may monitor the status for each or any of the vServers **275**A'-**275**N' at predetermined time intervals, for example once every 0.01, 0.1, 0.2, 0.5, or 1 seconds. In another embodiment, the appliance may monitor the status for each or any of the vServers **275**A'-**275**N' asynchronously or based on any events.

At step **920**, the appliance measures and monitors the bandwidth used by any of the vServers **275**A'-**275**N' receiving client communications directed from the first vServer **275**A. The load monitor **420** and/or bandwidth detector **802** may compute, determine or otherwise make bandwidth measurements **925**. In one embodiment, the appliance determines the measured bandwidth **825** of a vServer **275** on a predetermined frequency. In another embodiment, the appliance determines the measured bandwidth **825** of a vServer **275** triggered by an event. In one case, the appliance determines the measured bandwidth **825** of a vServer **275** at the request of a user. In some embodiments, the appliance **200** measures bandwidth based on a number of bytes transferred to and/or from a vServer **275**. In other embodiments, the appliance **200** measures bandwidth based on round trip times of communication to and/or from a vServer **275**. In some embodiments, the appliance may dynamically adjust the bandwidth threshold **820** based on bandwidth measurements. In other embodiments, the appliance may dynamically adjust the bandwidth threshold **820** based on performance and/or operational characteristics of the appliance, the vServer **275**, the network connection, and/or the service **270**.

At step **925**, the appliance may receive a client request. In some embodiments, the client request is for one or more objects having an object type **902**. In one embodiment, the client request includes a URL matching, identifying, associated with or corresponding to an object type **902**. In another embodiment, the client request includes a file name, reference, type or extension identifying or associated with an object type **902**. In one embodiment, the appliance intercepts the client request as a transparent interception device. In another embodiment, the client transmits the request to the appliance as a proxy. In other embodiments, the appliances receives a client request to access a service via a previously established transport layer connection. The transport layer request may be received from any computing device including a client **102**, server **106**, or a second appliance **200**. In one embodiment, the request may identify a type of service **270**, which may be associated with or other identify an object type **902**. In yet another embodiment, the appliance **200** applies a policy **903** to any portion or content the client request to identify or determine the object type **902**.

In other embodiments, the client request identifies a plurality of object types **902**A-**902**N. In these embodiments, the first vServer **275**A directing traffic to the other vServers **275**A'-**275**N' may split the request up according to each of the plurality of object types **902**A-**902**N. For example, the first vServer **275**A may directs a first portion of the request corresponding to a first object type to a second vServer **275**A', and a second portion of the request corresponding to a second object type to a third vServer **275**N'. In another example, the first vServer **275**A directs a first portion of the request identifying a first object type **902**A to vServer **275**A' while a second vServer **275**B directs a second portion of the request identifying a second object type **902**N to another vServer **275**N''. In some embodiments, the first vServer **275**A may direct a client request having a plurality of object types **902**A-**902**N to a single second vServer **275**A'. The handling of multiple object types **902**A-**902**N may be specified by a policy of which object type **902**A-**902**N has priority in switching decisions for virtual servers.

At step **930** the appliance may determine whether the measured bandwidth **825** for an object handling vServer **275**A'-**275**N' has reached or exceeded the corresponding bandwidth threshold **820**A-**920**N. For example, the appliance may compare the current measured bandwidth **825**A for the second first virtual server **275**A' handling a first object type **902** with the current value of the bandwidth threshold **820**A for the second virtual server. In other embodiments, the load monitor **420** and/or bandwidth detector **802** may have already determined the bandwidth threshold **925** for the second vServer **275**A' has been reached or exceeded. In another embodiment, the appliance **200** may determine if the bandwidth threshold **925** has been reached or exceeded responsive to receiving the client request. If the bandwidth threshold **820** of the second vServer **275**A', the appliance may provide the client request to the second virtual server at step **935**.

If the appliance determines the bandwidth threshold **820** of the second virtual server **275**A' has been exceeded, the appliance may establish, use or otherwise spillover to a third virtual server **275**N at step **940**. The third virtual server **275**N' may handle client requests corresponding to the object type of the second virtual server **275**A'. In other embodiments, a third virtual server **275**N' may already have been established prior to some or any of the steps shown. In another embodiment, the third virtual server **275**N may be established responsive to determining the bandwidth threshold **820** has been exceeded. The second virtual server may provide access to the object type **920** via a second plurality of services **270**. In one embodiment, one or more of the second plurality of services **270** may comprise the same type of service **270** as one or more of the first plurality of services. The appliance may then establish and/or adjust a bandwidth threshold **820** for the third virtual server. The appliance may provide the client request to the second virtual server **275**N' at step **955**.

In other embodiments, if the bandwidth threshold **820** of the second virtual server **275**A' has been exceeded, the appliance may redirect the client making the request to another resource. In one embodiment, the appliance may transmit a URL to the client comprising the address of a server **106** or service **270** such that the client may bypass the appliance **200** and access the server **106** or service **270** directly. In one embodiment, the appliance may transmit a URL to the client comprising the address of a second appliance **200**. In still another embodiment, the appliance **200** may redirect the client request to a second appliance.

At step **950**, the appliance **200** may determine whether the client making the request has a previously existing connection or session with either the first or a second virtual server. In some embodiments, an appliance may assign a priority to providing requests from a client to virtual servers that have previously serviced or are currently servicing connections or session from the client. For example, if a request is received from a client, and the client has a currently existing connection with a third virtual server **275**N', the appliance **200** may provide the request to the third virtual server even if the second virtual server **275**A' has reached or exceeded the bandwidth threshold. Or, for example, if a client has a previous connection via a backup virtual server, and the primary virtual server subsequently falls below the bandwidth threshold **820**, the appliance **200** may still provide a subsequent request from the client to the backup virtual server. In one embodiment, a connection management mechanism **610**, or other appliance component may track previously established or current connections or session so that incoming requests from a client can be provided to a virtual server having previously serviced the connection or session from the client.

At step **955**, the appliance **200** may dynamically manage virtual spillover based on bandwidth and object types by directing or providing the client request to the spillover or third vServer **275**N'. In some embodiments, the appliance determines the third vServer **275**N' handling a first object type is busy, unavailable or has exceeded its bandwidth threshold or another threshold. In response, the appliance may redirect the client at step **940** or provide the client request to a fourth vServer **275**B' handling the first object type or another appliance **200'**. In some embodiments, the appliance has a plurality of vServers **275**A'-**275**N' handling objects corresponding to an object type and determines which vServer to direct the client request based on comparison of each vServer's measured bandwidth and/or bandwidth threshold. In one case, the appliance provides the client request to one of a plurality of backup or spillover vServers configured to handle the object type based on the least measured bandwidth. In another case, the appliance provides the client request to the vServer handling the object type with the greatest difference between the measured bandwidth and the bandwidth threshold.

Although an embodiment of method **900** is generally described above in regards to measuring and monitoring bandwidth of a second vServer managed by a first vServer and spilling over to a third or fourth vServer, any steps of the method may be performed for the third spillover vServer, fourth spillover vServer and so on. An embodiment of method **1000** or any steps thereof may be practiced for a plurality of virtual servers managing a plurality of other virtual servers, each handling a plurality of object types. Another embodiment of the method or any steps thereof may be practiced for a chain of spillover virtual servers, so that a second vServer spills over into a third vServer based on bandwidth and object types, and the third vServer into a fourth vServer and so on.

Furthermore, any of the systems and method discussed herein may be practiced in combination. For example, the techniques of dynamic connection spillover management described in conjunction with FIGS. **6** and **9** may be practiced with the object based bandwidth based spillover management described in conjunction with FIGS. **9**A and **9**B. In some embodiment, the appliance may establish, monitor and manage spillover of virtual servers based on multiple thresholds. For example, the appliance may use both connection based thresholds and bandwidth based thresholds to determine to spillover from one virtual server to another for handling a client request identifying an object type. In one embodiment, the appliance may spillover from one virtual server to another virtual server when both thresholds are reached or exceeded and for a certain object type. For example, for processing client requests of a first object type, the second vServer managed by the first vServer may have a connection capacity threshold and a bandwidth threshold. Another object handling vServer may have different connection capacity threshold and/or bandwidth threshold. In another embodiment, the appliance may spillover from one virtual server to another virtual server for handling objects of a certain type when either of the thresholds are reached or exceeded.

G. Systems and Methods for Health Based Spillover

Referring now to FIGS. **10**A and **10**B, systems and methods for managing spillover from a first virtual server to a second virtual server based on health are depicted. The appliance may establish or user configure a health threshold for one or more virtual servers managing one or more services. The health threshold may be established or identified as a percentage. The appliance monitors the health of the services used by a virtual server. In response to detecting the health falling below the established health threshold, the appliance dynamically directs client requests to another virtual server. The health threshold may be adjusted to take into account capacity, response times, virtual server performance or performance of the server. The appliance manages virtual servers based on health to maintain performance of the virtual servers and the services managed by the virtual servers at a desired level or within a predetermined performance range.

Referring now to FIG. **10**A, an embodiment of an appliance or intermediary for providing virtual server spillover management based on health is depicted. In brief overview, the appliance **200** establishes a first vServer **275**A to manage access by a plurality of clients **102***a*-**102***n* to one or more services **270**A-**270**N of a first set of servers **106**A-**106**N. The appliance **200** includes a connection management mechanism **610** or connection manager for managing and balancing requests from clients **102***a*-**102***n* to one or more set of services **270**A-**270**N via one or more vServers **275**A-**275**N. The appliance **200** establishes for a first vServer **275**A a health threshold **1020**A, which may be specified by a user. The appliance may establish a second vServer **275**N with a second health threshold **1020**B. Via monitoring agents **420**A-**420**N, the appliance monitors the operational status of each of the services **270**A-**270**N. The monitoring agents **420** may include a health monitor **1002** for measuring the health used by a virtual server **275**. The health monitor **1002** may at predetermined frequencies or time frames determine a measured health **1025**A for a first vServer **275**A. The health monitor **1002** may also determine a measured health **1025**B for the second vServer **275**N.

If the measured health for the first vServer **275**A is determined to have reached or fallen below the health threshold **1020**A, the connection manager **610** of the appliance may determine to direct client requests to the second vServer **275**N. For example, a user may configure a health threshold at 50%. If the health detector **1020** determines the measured health **1025** of the vServer **275** falls below 50%, the appliance **200** via the connection management mechanism **610** may switch client requests to the second vServer **275**N.

Each of the vServers **275**A-**275***n* may identify or be configured to identify the one or more services the vServer is managing. In some embodiments services may be organized or configured into a group referred to as a service group or group of services. In some of these embodiments, a command, instruction, policy or configuration may be applied to each service in a service group by referencing the service group via the command, instruction, policy or configuration. In some embodiments, a service or a service group may be enabled or disabled by an administrator of the appliance. In other embodiments, a service or service group may be enabled or disabled by any component of the appliance, such as connection manager **610** or a monitoring agent **420**. In some embodiments, a service or service group may be referred to or considered a member of the vServer. In some embodiments, to have a service or service group be managed by a vServer, the service or service group may be bound to the vServer via any type and form of bind command or instruction. In some of these embodiments, a service may be referred to as bound to a vServer. In some embodiments, a service may be enabled or disabled but not bound to the vServer. In other embodiments, a service may be bound to a vServer but disabled.

Any of the services **270**A-**270**N' and/or service groups may be assigned any type and form of weight **1070**, such as any of the weights described in conjunction with FIGS. **4**A and/or **4**B. The weight may be any type and form of numerical factor identifying a relative degree of importance, influence, consideration or value. In some embodiments, each service may be assigned the same weight. In other embodiments, each service may be assigned a different weight. In some embodiments, some services are assigned the same weight while other services are assigned different weights. In one embodiment, a same or different weight may be assigned to any service group. In some embodiments, the weight assigned to a service group is assigned at the group level. For example, the service group may be considered a single entity with the assigned eight. In other embodiments the weight assigned to a service group is assigned to each of the services of the service group. For example, the services in the service group may be treated as separate entities each with the same weight assigned to the service group. In some embodiments, a sum of the weights **770** assigned to a service and/or service group may be equal to 100. In other embodiments, a sum of the weights **770** assigned to a service and/or service group may be any predetermined number greater than or less than 100.

In some embodiments, a service and/or service group may be assigned a different weight based on state: up/down (active/inactive), enabled/disabled, etc. In one embodiment, a service may have a first weight for an up state. In some embodiments, the service may have a second weight for a down state. In some embodiments, a service and/or service group may be assigned a different weight based on load. In another embodiment, the a service and/or service group may be assigned a progressively changing weight based on changes in state and/or load.

The health **1025**A-**1025**B, generally referred to as health **1025**, may be defined as a percentage of weights of services that are currently in an up state, sometimes referred to as active, to the sum total of the weights of all enabled services, such as those services that are either in an up or down state.

The down state is sometimes referred to as inactive. From a computational perspective, the health **1045** may be expressed or represented in logic or executable form as:

Health of a virtualServer=[(activeWeight of virtualServer)/totalWeight of virtualServer)]*100
where:

activeWeight of services for vServer **275**=sum of weights of services and/or service groups that are (a) active and, in some embodiments, also (b) enabled

totalWeight(virtual server)=sum of weights of services and/or service groups of the vServer **275** that are enabled.

The activeWeight parameter, input or value to the health determination may comprise the addition or summation of each of the weights assigned to each service and/or service group that is identified as in a predetermined state. In one embodiment, the predetermined state is up or active. The activeWeight value may be set to a resulting total of the addition or summation. In some embodiments, the service and/or service group must be enabled and in the predetermined state to be included in the addition or summation. In some embodiments, the service and/or service group must be bound and in the predetermined sate to be included in the addition or summation.

The totalWeight parameter, input or value to the health determination may comprise the addition or summation of each of the weights assigned to each service and/or service group that is assigned to the vServer. In some embodiments, those service and/or service groups that are enabled are included in the totalWeight computation. In some embodiments, those service and/or service groups that are bound to the vServer are included in the totalWeight computation. in some embodiments, those service and/or service groups that either have an up or down state are included in the totalWeight computation The sum of weights of services and/or service groups that are enabled may include all services that are either identified as 'UP' or 'DOWN'. In some embodiments, the sum of weights of services and/or service groups that are enabled may not includes those services which are marked disabled or otherwise configured to be disabled.

In some embodiments, the health is expressed numerically. In other embodiments, the health is expressed as text or string format. In some embodiments, health is expressed as a percentage, in the form X %, XX %, XXX %, In some embodiments, the range of health is from 0% to 100%. In some embodiments, health may be expressed as a percentage with any number of decimal places, such as X.X %, XX.XX % or XXX.XXX %. In other embodiments, health is expressed without multiplying by a 100 in the above equation. In these embodiments, health may be expressed as a percentage greater than 100%. In other embodiments, the health may be a number. In some embodiments, health may be a ratio. In one embodiment, health may be a fraction. In some embodiments, health may be a decimal.

The health monitor **1002**, sometimes referred to as a health detector or detector, includes or provides logic, business rules, functions or operations for determining the health of one or more virtual servers **275**. The health detector **1002** may include software, hardware or any combination of software and hardware. The health detector **1002** may comprise an application, program, script, library, process, service, driver, task, thread or any type and form of executable instructions. In some embodiments, the health monitor is a monitoring agent. In another embodiment, the health monitor is part of a monitoring agent. In still another embodiment, the health monitor may be part of the vServer. In yet another embodiment, the health monitor may be a separate component of the appliance in communication with any one or more of the monitoring agent, vServer and/or connection manager.

In some embodiments, the health detector **1002** determines or computes the health **1020**. The health detector **1002** may determine the health on a predetermined frequency. In some embodiments, the health detector **1002** determines an average health over any period of time In other embodiments, the health detector **1002** measures the health **1025** for a vServer **275** based on the number of packets on a queue waiting to be transmitted. In some embodiments, the health detector **1002** determines health upon the transition of a queue of network packets from empty to non-empty and vice-versa. In some embodiments, the health detector **1002** determines health upon receipt of a client request. In some embodiments, the health detector **1002** determines health upon receipt of a server response.

The health detector **1002** may determine the health of a vServer responsive to any one or more monitoring agents. For example, in some embodiments, the health detector may compute/recompute the health upon return of a status of a service from a monitoring agent. In another embodiment, the health detector may compute/recompute the health upon a change in status of a service from a monitoring agent. In some embodiments, the health detector may determine the health at a configured or configurable predetermined frequency. In some embodiments, the health detector may determine the health at different times or different frequencies for each vServer. In yet another embodiment, the health detector may use different health computations among a plurality of vServers. For example, in some embodiments, the type and form of the health computation may be configurable or specified by policy.

In some embodiments, the health detector **1002** determines, computes or establishes the totalWeight of health a first time and updates the totalWeight of services upon a change in the enabled or disabled state of a service or service group. In some embodiments, the health detector **1002** determines, computes or establishes the totalWeight of health a first time and updates the totalWeight of services upon a change in the weight of any of a service or service group. In other embodiments, the health detector **1002** determines, computes or establishes the totalWeight any type a health determination or computation is made.

The health threshold **1020** for a vServer **275** may be specified as a number, such as a real or integer. In some embodiments, the health threshold **1020** may be expressed as a percentage. In other embodiments, the health threshold **1020** may be expressed as a ratio or a decimal. For example, the health threshold **1020** may represent a percentage of enabled services active and used by the vServer **275**. In another example, the health threshold **1020** may represent a percentage of health available to the vServer **275**. In some embodiments, the health threshold may be expressed logically using any type and form of expression, such as for example, "health<20%".

In some embodiments, the health threshold **1020** may indicate a relative percentage from a predetermined point. In one embodiment, the health threshold **1020** identifies an amount of change of the measured health. For example, the health threshold **1020** may represent an amount of decrease in percentage of health to be considered triggering the threshold. In another embodiment, the health threshold **1020** may indicate an average health value to maintain. In some embodiments, the health threshold **1020** may indicate an average health value over a period of time. In other embodiments, the health threshold **1020** may indicate a relative percentage of services that change from an active to inactive state or from an up to a down state.

The connection management mechanism **610**, also referred to as a connection manager or a virtual server switch, comprises software, hardware, or any combination of software and hardware having logic, functions or operations for receiving and managing requests, connections and communications from one or more clients **102**A-**102**N. In one embodiment, the connection manager **610** receives or intercepts transport layer connection requests and/or communications between the clients **102**A-**102**N and one or more services **270**A-**270**N. The connection manager **610** may include an application, program, service, process, task, thread or any type and form of executable instructions. In response to receiving a client communication, the connection manager **610** identifies, determines or selects a vServer **275** for processing a received communication from a client **102**.

The connection manager **610** may operate responsive to the load monitor **420** and/or the health detector **1002**. The load monitor **420** may monitor the measured health **1025**. In some embodiments, the load monitor **420** and/or health detector **1002** measures the health on a predetermined frequency. In one embodiment, the load monitor **420** and/or health detector **1002** measures the health responsive to any events, such as receipt of a network packet. In other embodiments, the load monitor **420** and/or health detector **1002** may determine whether or not the measured health **1025** is less than the health threshold **1020**.

If the connection manager **610** determines from the load monitor **420** and/or health detector **1002** that the measured health **1025** of a first vServer **275**A falls below the health threshold **1020**, the connection manager **610** directs client requests for the services managed by the first vServer **275**A to a second vServer **275***n*. The second vServer **275***n* may be configured or established as backup server to the first vServer **275**A. For example, the first vServer **275**A may be designated a primary vServer **275**A and the second vServer **275**N as backup vServer **275**N. In another embodiment, the second vServer **275**N may be another virtual server—primary, redundant, or otherwise—for managing the services **270**A-**270**N. In yet another embodiment, the second vServer **275**N is configures or designated as the spillover virtual server for the first vServer **275**A. In some cases, the second vServer **275**N is established upon determining the first vServer **275275**A fall below the health threshold **1020**. In other cases, the vServer **275**N is already operating or executing on the appliance **200**.

In some embodiments, the connection manager **270** directs new client request requests to the second vServer **275**. In one embodiment, if the request is from a connection already established with the first vServer **275**A, the connection manager **610** may direct the request to the first vServer **275**A even if the health threshold **1020** is exceeded or fallen below. This may be referred to as connection or session persistence. In another embodiment, the connection manager **610** directs any client requests to the second vServer **275**, for example, even a request of a previously established connection.

In one embodiment, the connection manager **610** directs client requests to the second vServer **275**N while the first vServer **275** has a measured health **1025** greater than the health threshold **1020**. In another embodiment, the connection manager **610** directs clients requests back to the first vServer upon determining that the measured health **1025** of the first vServer **275** has increased above the health threshold **1020**. In some embodiment, the connection manager **610** determines which of the first vServer **275**A and the second vServer **275**N has the highest health or is the least nearest to the corresponding health threshold **1020** and directs the client requests to the determined vServer. In other embodiments and in the case of multiple vServers **275**A-**275**N falling below a health threshold **1020**, the connection manager **610** determines which vServer **275**A-**275**N falls below its corresponding threshold **1020** the least and directs the client requests to the determined vServer.

Upon detecting the health threshold **1020** has been reached for the first vServer **275**A and/or the second vServer **275**N, the connection management mechanism **610**, in one embodiment, may determine not to establish another spillover vServer **275**N but instead redirects the client **102** directly to a server **106** or otherwise to bypass the appliance **200**. For example, the connection management mechanism **610** may determine the health threshold **1020**B for the spillover vServer **275**N has been reached and may redirect the client **102** to bypass the appliance **200** instead of establishing a third vServer **275**N for spillover. In these embodiments, the connection management mechanism **610** may transmit a redirect Uniform Resource Locator (URL) **660** to the client **102** for the client **102** to connect to in response to the client's connection request. The URL **660** may identify any one of the servers **106** or services **270**.

In some embodiments, the appliance **200** via a load monitor **420** and/or health detector **1002** measures and monitors the health of the second virtual server **275**N. The second vServer **275**N may have the same health threshold **1020** or a different health threshold **1020** as the first vServer **275**A. If the connection manager **610** determines from the load monitor **420** and/or health detector **1002** that the measured health **1025**N of the second vServer **275**N falls below the health threshold **1020**, the connection manager **610** directs client requests for the services managed by the second vServer **275**A to another vServer **275**N, such as the first vServer **275**A or a third vServer **275**B. The second vServer **275**N may have a third vServer **275**B designated as backup virtual server or a spillover virtual server. The health threshold management techniques described herein may be used for a chain or plurality of virtual servers and spillover virtual servers, each with a health threshold and designated backup or spillover virtual server.

The appliance via the connection manager directs client requests to the primary vServer **275** or any backup or spillover vServer **275** based on measured health **1025** in view of the established health threshold **1020**. The appliance **200** may dynamically adjust any health threshold **1020** for any vServer **275** based on any performance or operational characteristics of the appliance, vServer, bandwidth, network connection, client or server. In one embodiment, the appliance may determine that the established health threshold **1020** is set relatively low in comparison to the measured health **1025** and determines to dynamically increase the health threshold **1020**. For example, the appliance may adjust to the health threshold **1020** within a certain percentage or threshold of the measured health. In another embodiment, the appliance may determine that the established health threshold **1020** is set relatively high in comparison to the measured health **1025** and determines to dynamically decrease the health threshold **1020**.

In one case, the appliance **200** dynamically sets or establishes a health threshold **1020** by measuring health **1025** of a vServer **275** for a predetermined time period. For example, upon startup of a vServer **275**, the health detector **1002** may measure health for a predetermined or configured time period, and then based on an average, peak or range of health measurements set the health threshold **1020**. In another case, the appliance **200** may dynamically adjust a health threshold **1020** based on adding or removing services **270**A-**270***n* managed by a vServer **275**. In still other embodiments, the appliance **200** may dynamically adjust the health threshold **1020** of a vServer **275** based on information and feedback from a monitoring agent **197** and/or monitoring service **198**. In still other embodiments, the appliance **200** may dynamically adjust health thresholds **1020** based on one or more policies of a policy engine **195**.

In some embodiment, the appliance **200** excludes a vServer **275** from a load computation or determination, or otherwise a load balancing decision if the health **725** of the vServer **275** falls below the health threshold **1020**. In these embodiments, this may be done so that the other vServer **275**A-**275**N which carry the load for the excluded vServer **275** do not also become overloaded. In other embodiments, the appliance **200** adjusts a weight used for the vServer **275** upon detecting the vServer's bandwidth **1025** exceeds the health threshold **1020**. For example, the weight of the vServer **275** may be adjusted to minimize the impact to the other vServer **275**A-**275**N for not having the vServer **275** available to also service requests.

In some embodiments, the appliance or any component thereof may adjust any one or more weight of any one of the services or service groups and then recompute the health. The appliance **200** may dynamically adjust any weight any service or service group based on any performance or operational characteristics of the appliance, vServer, bandwidth, network connection, client or server.

Referring now to FIG. **10**B, an embodiment of steps of a method for practicing dynamic virtual server spillover management based on health is depicted. In brief overview, at step **905**, the appliance establishes a first virtual server **275**A which directs requests from a plurality of clients to a plurality of services. At step **910**, the appliance establishes a health threshold for the first virtual server. At step **915**, the appliance monitors a status for each of the plurality of services. At step **950**, the appliance measures and monitors the health **1025** of the first vServer **275**. At step **925**, the appliance receives a client request. At step **930**, the appliance determines whether or not the health threshold for the first vServer **275**A has been exceeded. If not, at step **935**, the appliance directs the client request to the first vServer **275**A. If the threshold has been exceeded, the appliance at step **940** determines whether or not to establish or use a second vServer **275**N or provide a redirect URL to the client **102**. In one case, at step **945**, the client is redirected to the service and bypasses the first vServer **275**A. At step **950**, the appliance may determine if the client is persistent (referred to as being sticky) with the first vServer **275**A or the second vServer **275**N. If the client is sticky to the first vServer **275**A, the appliance may direct the request to the first vServer **275**A at step **935**. Otherwise, the appliance spills over to an established second vServer **275**N at step **955**. The method may continue at step **910** to monitor and perform health based spillover management for the second vServer **275**N.

In further detail, at step **905**, an appliance establishes a first virtual server **275** which manages connections and direct requests from a plurality of clients to a first plurality of services **270**. In one embodiment, the appliance may establish the virtual server upon startup of the appliance. In another embodiment, the appliance may establish the virtual server in response to a previously established virtual server exceeding maximum connection threshold. In one embodiment, the appliance may establish a plurality of virtual servers. In some embodiments, a user configures and starts the first vServer **275**. In other embodiments, the first vServer is configured, established or designed by the appliance or a user as a primary virtual server.

At step **910**, the appliance may establish or otherwise provide a health threshold **1020** for the first vServer **275**. In one embodiment, the health threshold **1020** may be initially configured by a user or administrator of the appliance. In another embodiment, the health threshold **1020** may be initially determined by the appliance by monitoring the health of the vServer **275** or by polling one or more services **270**. In some embodiments, the appliance **200** may use a default or predetermined health threshold **1020**. For example, the appliance may use a predetermined health threshold **1020** associated with or based on the type of service **270**.

At step **915**, the appliance may monitor a status for each of the services **270** using any means. In one embodiment, the appliance may use a monitoring agent **420**. In another embodiment, the appliance may use a plurality of monitoring agents **420**. In one embodiment, the appliance may monitor the status for each of the services at predetermined time intervals, for example once every 0.01, 0.1, 0.2, 0.5, or 1 seconds. In another embodiment, the appliance may monitor the status for each of the services **270** asynchronously or based on any events.

At step **920**, the appliance measures and monitors the health of the first vServer **275**A. The load monitor **420** and/or health detector **1002** may compute, determine or otherwise make health measurements **1025**. In one embodiment, the appliance determines the measured health **1025** of a vServer **275** on a predetermined frequency. In another embodiment, the appliance determines the measured health **1025** of a vServer **275** triggered by an event. In one case, the appliance determines the measured health **1025** of a vServer **275** at the request of a user. In some embodiments, the appliance **200** measures health as a percentage using any of the health computations described in connection with FIG. **10**A. In some embodiments, the appliance may dynamically adjust the health threshold **1020** based on health measurements. In other embodiments, the appliance may dynamically adjust the health threshold **1020** based on performance and/or operational characteristics of the appliance, the vServer **275**, the network connection, and/or the service **270**.

At step **925**, the appliance may receive a client request. In one embodiment, the appliance intercepts the client request as a transparent interception device. In another embodiment, the client transmits the request to the appliance as a proxy. In some embodiments, the appliance receives a client request to open or establish a transport layer connection. In other embodiments, the appliances receive a client request to access a service via a previously established transport layer connection. The transport layer request may be received from any computing device including a client **102**, server **106**, or a second appliance **200**. In one embodiment, the request may identify a type of service **270**. For example, the request may comprise a request for HTTP service. Or, for example, the request may comprise a request for UDP service.

At step **930** the appliance may determine whether the measured health **1025** for a vServer **275** has reached or fallen below the health threshold **1020**. The appliance may compare the current measured health **1025** for the first virtual server with the current value of the health threshold **1020** for the first virtual server. In other embodiments, the load monitor **420** and/or health detector **1002** may have already determined the health threshold **1025** for the vServer **275** has been reached or exceeded. In another embodiment, the appliance **200** may determine if the health threshold **1025** has been reached responsive to receiving the client request. If the health threshold **1020** of the first virtual server has not been reached, the appliance may provide the client request to the first virtual server at step **935**.

If the appliance determines the health threshold **1020** of the first virtual server has been reached, the appliance may establish, use or otherwise spillover to a second virtual server **275**N at step **940**. In other embodiments, a second virtual server **275**N may already have been established prior to some or any of the steps shown. In another embodiment, the second virtual server **275**N may be established responsive to determining the health threshold **1020** has been reached. The second virtual server may provide access to a second plurality of services **270**. In one embodiment, one or more of the second plurality of services **270** may comprise the same type of service **270** as one or more of the first plurality of services. The appliance may then establish and/or adjust a health threshold **1020** for the second virtual server. The appliance may provide the client request to the second virtual server **275** at step **955**.

In other embodiments, if the health threshold **1020** of the first virtual server has been reached, the appliance may redirect the client making the request to another resource. In one embodiment, the appliance may transmit a URL to the client comprising the address of a server **106** or service **270** such that the client may bypass the appliance **200** and access the server **106** or service **270** directly. In one embodiment, the appliance may transmit a URL to the client comprising the address of a second appliance **200**. In still another embodiment, the appliance **200** may redirect the client request to a second appliance.

In another embodiment, the appliance identifies that the measured health exceeds the health threshold and directs client requests to the first vServer. In some embodiments, the appliance identifies that one or more services that were previously down and the measure health now exceeds the health threshold. In response to the health reaching or being above the health threshold, the appliance may direct client request to the first vServer instead of the second vServer.

At step **950**, the appliance **200** may determine whether the client making the request has a previously existing connection or session with either the first or a second virtual server. In some embodiments, an appliance may assign a priority to providing requests from a client to virtual servers that have previously serviced or are currently servicing connections or session from the client. For example, if a request is received from a client, and the client has a currently existing connection with a first virtual server, the appliance **200** may provide the request to the first virtual server even if the first virtual server has reached or exceeded the bandwidth threshold. Or, for example, if a client has a previous connection via a backup virtual server, and the primary virtual server subsequently falls below the health threshold **1020**, the appliance **200** may still provide a subsequent request from the client to the backup virtual server. In one embodiment, a connection management mechanism **610**, or other appliance component may track previously established or current connections or session so that incoming requests from a client can be provided to a virtual server having previously serviced the connection or session from the client.

At step **955**, the appliance **200** may dynamically manage virtual spillover based on health by directing or providing the client request to the spillover or second vServer **275**N. In some embodiments, the appliance determines the second vServer **275** is busy, unavailable or has exceeded its health threshold or another threshold. In response, the appliance may redirect the client at step **940** or provide the client request to a third vServer **275**B or another appliance **200'**. In some embodiments, the appliance has a plurality of vServers **275**A-**275**N managing the services **270** and determines which vServer to direct the client request based on comparison of each vServer's measured health and/or health threshold. In one case, the appliance provides the client request to one of a plurality of backup or spillover vServers based on the best measured health. In another case, the appliance provides the client request to the vServer with the greatest difference between the measured health and the health threshold.

Although an embodiment of method **1000** is generally described above in regards to measuring and monitoring health of a first vServer and spilling over to a second vServer, any steps of the method may be performed for the second vServer and a spillover server for the second vServer, and for a third vServer, and so on. An embodiment of method **1000** or any steps thereof may be practiced for a plurality of virtual servers, such as a set of primary vServer managing the same or different services. Another embodiment of method **1000** or any steps thereof may be practiced for a chain of spillover virtual servers, so that a second vServer spills over into a third vServer based on health and so on.

H. Systems and Methods for Handling Spillover in Conjunction with Limit Parameters in a Multi-Core System

The systems and methods of the solution described herein are directed towards handling spillover in conjunction with limit parameters for resources used by a plurality of cores in a multi-core system. In general overview, a pool manager allocates a limited number of uses of a resource across a plurality of packet processing engines operating on a plurality of cores of a multi-core system. The pool manager divides the limited number of uses into an exclusive quota pool and a shared quota pool. The pool manager allocates to each packet processing engine an exclusive number of uses of a resource, wherein each exclusive number may be taken from the exclusive quota pool. Each packet processing engine may use the resource up to its exclusive number of uses without further restrictions.

If a packet processing engine wishes to increase its use of the resource beyond the exclusive number of uses, the packet processing engine may request to the pool manager to borrow uses from the shared quota pool. The pool manager may grant the packet processing engine a batch number of uses from the shared quota pool. When the packet processing engine completes one or more uses of the resources, the packet processing engine may return borrowed uses (also referred to herein as "quota") to the shared quota pool.

At times, the pool manager may have already granted all the uses from the shared quota pool to one or more packet processing engines. In these situations, the pool manager may evaluate the packet processing engines to determine if one of the engines have available exclusive uses of the resource. The pool manager may select an engine as the spillover engine for the packet processing engine seeking another use of the resource. Thus, the request to use the resource is redirected to and serviced by the spillover packet processing engine. As a result, while a limited number of uses for a resource is being distributed across a plurality of cores on a multi-core system, a core receiving heavy traffic may nevertheless spillover into another core that services the requests.

Referring now to FIG. **11**, a block diagram of an embodiment of a multi-core system **1145** that handles a limit parameter for one or more resources is depicted. The multi-core system **1145** may comprise any of the embodiments of the multi-core system of FIG. **5**B. The multi-core system may include a pool manager **1165** operating on any portion of the multi-core system, such as any core, packet engine, or the flow distributor. One of the cores **505** may be designated a master core for which the pool manager **1165** operates. The other cores may also run a pool manager **1165** for communicating with the master core regarding the use of the resource. The pool manager **1165** may manage the use of a resource and limits thereof via an exclusive quota pool **1170** and/or a shared quota pool **1175**.

The pool manager **1165** may comprise any program, application, process, task or set of executable instructions for managing, allocating, distributing, and/or controlling the use of a resource via quota pools. The pool manager **668** may determine the limit for the number of uses of the resource, the exclusive quota pool **1170**, and the shared quota pool **1175**. The pool manager **668** may allocate batch numbers of uses to packet processing engines **548** from the shared quota pool **1175**.

In some embodiments, the pool manager **1165** executes on a master core. In other embodiments, the pool manager **1165** executes as part of the flow distributors **550**. In some embodiments, the pool manager **1165** executes as part of a packet processing engine **548**. In various embodiments, the pool manager **1165** may include a plurality of pool managers, each of which may execute on a respective core of the plurality of cores. The pool manager **1165** on the master core may control and allocate the use of resources via the quota pools. Any pool manager **1165** on any secondary core may request and receive an allocation of the use of resources from the pool manager **1165** of the master core. In some embodiments, a pool manager **1165** on any secondary core may request uses from the exclusive quota pool **1170** allocated to the secondary core. In other embodiments, a pool manager **1165** on any secondary core may request a batch number of uses from the shared quota pool **1175**.

The pool manager **1165** on any secondary core may determine when the secondary core has reached its exclusive number of uses of the resource. In some embodiments, the pool manager **1165** may communicate with the pool manager **1165** on the master core to determine the availability of uses in the shared quota pool **1175**. In some embodiments, the pool manager **1165** on any secondary core may detect when the secondary core has completed a use of a resource and whether the secondary core has borrowed from the shared quota pool **1175**. In these embodiments, the pool manager **1165** may determine if the secondary core should return quota to the shared quota pool **1175**.

The exclusive quota pool **1170** may include a predetermined number of uses that may be assigned or allocated to a core or packet engine exclusively and/or without restrictions. In one aspect, the exclusive quota pool provides a number of exclusive uses to a resource. In some embodiments, an allocation of an exclusive use from the exclusive quote pool to a specific core or packet engine may not be shared or used by another core or packet engine. Exclusive uses from the exclusive quota pool **1170** may be divided or allocated across the plurality of cores **505** in any manner. In some embodiments, each core **505** may be assigned an exclusive number of uses of the resource. In some embodiments, the exclusive quota pool **1170** may include a plurality of exclusive quota pools. Each exclusive pool including an exclusive number of uses for a respective core **505** or packet engine of that core.

The shared quota pool **1175** may include a predetermined number of uses that may be shared and/or allocated to any core or packet engine in a non-exclusive manner. In one aspect, the shared quota pool provides a number of non-exclusive uses to a resource. In some embodiments, an allocation of a shared use from the shared quote pool to a specific core or packet engine may be returned to the shared quota pool to be used by another core or packet engine. In some embodiments, a core **505** may access the shared quota pool after the core **505** has reached its exclusive number of uses of the resource. The shared quota pool **1175** may be accessed by any core in the plurality of cores **505**. A core **505** that has reached its exclusive number of uses may borrow from the shared quota pool **1175**. The core **505** may request to borrow uses from the shared quota pool **1175** by sending a request to the pool manager **1165**. The pool manager **1165** may determine if the shared quota pool **1175** has available uses of the resource. If uses of the resource are available, the pool manager **1165** may allocate a batch number of uses to the core **505**. The pool manager **1165** may decrement the available number of uses of the resource by the batch number of uses. In some embodiments, the core **505** may implement a lock upon borrowing uses from the shared quota pool **1175**. When the core **505** completes its use of a resource, the core **505** may determine if it has borrowed from the shared quota pool **1175** and return quota.

The pool manager **1165** may allocate the limited uses of the resource among the exclusive quota pool **1170** and the shared quota pool **1175** in any manner by any algorithm or decision making process. In some embodiments, the pool manager **1165** may make the allocation according to user input that configures the quota pools. For example, a user may input a percentage to designate the percentage of the limit to be exclusive or shared. The user may input a number to designate the number of exclusive uses for each core. The user may input a number to designate the number of uses for the shared quota pool **1175** such that the remaining uses may be placed in the exclusive quota pool **1170**. In other embodiments, the pool manager **1165** may make the allocation according to a predetermined number coded into the pool manager **1165**. In some embodiments, the pool manager **1165** may make the allocation according to the performance of the multi-core system. In these embodiments, the pool manager **1165** may evaluate a metric associated with the performance of the multi-core system and adjust the allocation of uses between the exclusive quota pool **1170** and the shared quota pool **1175**.

The pool manager **1165** may manage the uses of any type or kind of resource. In some embodiments, the pool manager **1165** may manage the number of connections running in parallel to a service. In some embodiments, the pool manager **1165** may manage the connection capacity each core may access. In other embodiments, the pool manager **1165** may manage the bandwidth of the multi-core system. In additional embodiments, the pool manager **1165** may manage the number of bytes per second being processed by the cores **505**. In various embodiments, the pool manager **1165** may manage the number of packets per second being processed by the cores **505**. In various embodiments, the pool manager **1165** may manage any type or form of resource use as described in reference to FIGS. **6-10**.

Referring now to FIG. **12**A, a flow diagram depicting steps of an embodiment of a method for allocating limited numbers of uses of resources to a plurality of packet processing engines operating on a plurality of cores is shown and described. In brief overview, the method includes identifying (step **1201**) a limit for a number of uses of a resource across a plurality of packet processing engines. The method further includes establishing (step **1203**) an exclusive quota pool for the resource based on the limit. The method further includes establishing (step **1205**) a shared quota pool for the resource based on the limit. The method further includes establishing (step **1207**) a batch number of uses to be provided from the shared quota pool. The method further includes allocating (step **1209**) an exclusive number of uses from the exclusive quota pool to a packet processing engine operating on a core.

The pool manager **1165** may identify the limit for the number of uses of a resource. This limit may be for the use of the resource across the multi-core system, the plurality of cores and/or packet engines, or any portion thereof. In some embodiments, a user inputs the limit to the appliance **200**. The user may input the limit through the graphical user interface (GUI) **210** or the command line interface (CLI) **212** as described in FIG. **2**A. The limit may be any type and form of threshold on a number of uses of the resource. In some embodiments, the pool manager **1165** identifies the limit according to a parameter of the data communication network. In many embodiments, the pool manager **1165** identifies the limit as the maximum dynamic connection threshold, bandwidth threshold, and/or health threshold described in reference to FIGS. **6-10**.

In various embodiments, the limit may represent a maximum capacity of the resource. In some embodiments, the limit may represent a physical capacity of the resource. In other embodiments, the limit may represent a processing capacity of the resource. For example, the limit may be a maximum number of connections that may run in parallel to a service. In many embodiments, the limit for a number of uses for a resource may be absolute. Also the limit may simply be a desired limit. The limit may represent a percent of or a predetermined threshold of a capacity of the resource. When the total number of uses of the resource reaches the limit, the resource may deny further requests to use the resource.

The pool manager **1165** may establish the exclusive quota pool for the resource based on the limit. In various embodiments, the pool manager **1165** establishes the exclusive quota pool by applying a function to the limit. In many embodiments, the exclusive quota pool may be a predetermined percentage of the limit. In one example, the exclusive quota pool may be established as 80% of the limit. If the number of connections that may run in parallel to a service has a limit of 100, the exclusive quota pool may be 80 connections. In various embodiments, the exclusive quota pool may be established as the largest multiple of the number of cores less than a predetermined percentage of the limit. In one example, the limit is 100 connections to a service, the predetermined percentage is 80%, and the multi-core system has 7 cores. As 80 connections cannot be evenly distributed among 7 cores, the exclusive quota pool is established as 77 connections, the largest multiple of 7 that is less than 80.

The pool manager **1165** may establish the shared quota pool for the resource based on the limit. The shared quota pool may be established by subtracting the exclusive quota pool from the limit. The pool manager **1165** may implement the shared quota pool in a memory shared among the cores. In some embodiments, the pool manager **1165** may implement the shared quota pool using a data structure. The data structure may include variables associated with the limit and the function applied to the limit that establishes the exclusive quota pool. The data structure may include a variable associated with the number of uses in the shared quota pool. The data structure may include a variable associated with the available number of uses in the shared quota pool. The data structure may include variables associated with the identity of one or more packet processing engines **548** borrowing uses from the shared quota pool. The data structure may include variables associated with the number of uses being used by each of the identified packet processing engines.

The pool manager **1165** may establish the batch number of uses to be provided from the shared quota pool. The batch number of uses may be the number of uses a packet processing engine borrows whenever the packet processing engine accesses the shared quota pool. The pool manager **1165** may establish the batch number by applying a formula to the shared quota pool. In one embodiment, the batch number of uses may be 10% of the shared quota pool. If the shared quota pool is, for example, 20 connections to a service, the batch number is 2 connections. In another embodiment, the batch number of uses may be 20% of the shared quota pool, thereby resulting in a batch number of 4 for a shared quota pool of 20 connections. In various embodiments, if the application of the formula to the size of the shared quota pool results in a batch number less than 1, the batch number defaults to 1.

The pool manager **1165** may allocate an exclusive number of uses from the exclusive quota pool to each packet processing engine **548**. The exclusive number of uses may be the number of times a packet processing engine **548** may use the resource without further restrictions. If the packet processing engine **548** wishes to use the resource beyond its exclusive number, the packet processing engine **548** must borrow a batch number of uses, if available, from the shared quota pool. The pool manager **1165** may establish the exclusive number of uses based on the exclusive quota pool. The exclusive number of uses may be established by dividing the exclusive quota pool by the number of cores. If the exclusive quota pool divided by the number of cores is less than 1, then the exclusive number of uses becomes 0. In these embodiments, all the uses of the resource will belong to the shared quota pool, and each packet processing engine **548** must borrow from the shared quota pool whenever the packet processing engine **548** wishes to use the resource.

Referring now to FIG. **12**B, a flow diagram depicting steps of an embodiment of a method for borrowing from a shared quota pool is shown and described. In brief overview, the method includes receiving (step **1211**) a request to use a resource. The method also includes determining (step **1213**) if the packet processing engine will exceed its exclusive number of uses by fulfilling the request. If the packet processing engine will not exceed its exclusive number of uses, the method also includes fulfilling (step **1215**) the request to use the resource. If the packet processing engine will exceed its exclusive number of uses, the method also includes requesting (step **1217**), a batch number of uses from the shared quota pool. If the packet processing engine receives the batch number of uses, the engine fulfills the request (**1215**). If the pool manager determines the shared quota pool has been exhausted, the pool manager selects a packet processing engine with available exclusive uses as a spillover engine (step **1218**). The spillover engine fulfills the request (step **1219**).

The multi-core system **545** may receive the request to use the resource. The multi-core system **545** may assign the request to any core **505** of the plurality of cores. The multi-core system **545** may assign the request to a core **505** based on the type of request, the number of requests each core is processing, or any other basis. The request to use the resource may include a request to open a connection to a service. In any of these embodiments, the packet processing engine **548** operating on a core **505** may process the request.

The packet processing engine **548** may determine if the packet processing engine **548** will exceed its exclusive number of uses by fulfilling the request. In various embodiments, the packet processing engine **548** makes the determination by comparing its exclusive number of uses to its current number of uses. If the current number of uses +1 is less than or equal to the exclusive number of uses, the determination is negative. Otherwise, the determination is positive. In many embodiments, the packet processing engine **548** may maintain the number of its current uses in a non-shared memory. In some embodiments, the packet processing engine **548** may include a counter with the number of its current uses of the resource.

If the determination is negative, the packet processing engine **548** may fulfill the request to use the resource. If the determination is positive, the packet processing engine **548** may request a batch number of uses from the shared quota pool before fulfilling the request. In various embodiments, the packet processing engine **548** may send a request for a batch number of uses to the pool manager **1165**. The pool manager **1165** may determine if the shared quota pool has an available batch number of uses. The pool manager **1165** may allocate a batch number of uses from the shared quota pool to the requesting packet processing engine **548**. The pool manager **1165** may subtract a batch number of uses from the number of available uses in the shared quota pool. The pool manager **1165** may send a message to the packet processing engine **548** indicating that the request for a batch number of uses has been granted. In some embodiments, the packet processing engine **548** may acquire a lock before fulfilling the request with one of the batch number of uses borrowed from the shared quota pool. In various embodiments, the packet processing engine **548** sets a variable indicating that the packet processing engine has borrowed uses from the shared quota pool.

In other embodiments, the pool manager **1165** may determine that the shared quota pool does not have a batch number of uses available. In some embodiments, the pool manager **1165** may send a message to the packet processing engine **548** indicating that the request for a batch number of uses cannot be fulfilled. In some embodiments, the pool manager **1165** may place the request for a batch number of uses and the identity of the requesting packet processing engine **548** in a queue. In some embodiments, the request for a batch number of uses in the queue may time out after a predetermined period of time.

In various embodiments, the packet processing engine **548** may resend the request for a batch number of uses after a predetermined period of time. In some embodiments, the packet processing engine **548** may place the request to use the resource in a queue. In some embodiments, the request in the queue may time out after a predetermined period of time. In various embodiments, the packet processing engine **548** may send a message to the source of the request to use the resource indicating that the request cannot be fulfilled at that time.

If the pool manager determines the shared quota pool has been exhausted, the pool manager selects a packet processing engine with available exclusive uses as a spillover engine (step **1218**). In some embodiments, the pool manager may ping each packet processing engine to determine if the engine has available exclusive uses. In other embodiments, the pool manager may retrieve from a memory the number of exclusive uses each packet processing engine is using. The pool manager may select as the spillover engine the engine using the fewest number of exclusive uses. The pool manager may select engines to serve as spillover engines in a round robin method. In some embodiments, the pool manager selects the first detected engine using less than its exclusive number of uses to be the spillover engine.

Once the spillover engine is selected, the pool manager may store the identities of the spillover engine and the engine being supported by the spillover engine. The pool manager may also store identifying information about the request to use the resource, such as a source IP address of the client and/or session identifier. Then, the pool manager forwards the request to the spillover engine for fulfillment (step **1219**).

In various embodiments, the multi-core system may maintain connection or session persistence between a client **102** and the spillover packet processing engine handling requests for the client **102**. In some embodiments, the multi-core system selects the spillover packet processing engine for handling a client request even though the packet processing engine that needed spillover support no longer exceeds its exclusive number of uses and/or the shared quota pool has uses to be allocated. In other embodiments, the multi-core system selects the original packet processing engine for handling a client request even though requests from other clients are directed to the spillover packet processing engine. In one embodiment, the multi-core system may select the original or spillover packet processing engine based on which engine most recently handled a request from the client **102**.

Referring now to FIG. **12**C, a flow diagram depicting steps of an embodiment of a method for returning quota to a shared quota pool is shown and described. In brief overview, the method includes detecting (step **1221**) that use of a resource has been completed. The method also includes determining (step **1223**) if the packet processing engine borrowed from the shared quota pool. The method also includes, if the determination is negative, completing (step **1225**) the use of the resource. The method also includes, if the determination is positive, determining (step **1227**) if the number of completed uses of the resource is greater than or equal to the batch number. If the number of completed uses is not greater than or equal to the batch number, the packet processing engine completes the use of the resource. If the number of completed uses is greater than or equal to the batch number, the method includes returning (step **1229**) a batch number of uses to the shared quota pool in conjunction with completing (step **1225**) the use of the resource.

In further detail, the packet processing engine **548** may detect that use of a resource has been completed. In some embodiments, the resource sends a message to the packet processing engine **548** indicating that the use has been completed. In other embodiments, the packet processing engine **548** determines that a use has been completed after a predetermined amount of time. In these embodiments, the packet processing engine **548** determines a use has been completed because the use has timed out. In some embodiments, the packet processing engine **548** may receive a message from the source of the request to use the resource indicating that the request has been aborted.

The packet processing engine **548** may determine if the packet processing engine **548** borrowed from the shared quota pool in one of many ways. In some embodiments, the packet processing engine **548** may compare the number of its current uses of the resource to its exclusive number of uses. If the number of current uses exceeds the exclusive number of uses, the packet processing engine **548** may determine that borrowing occurred. In additional embodiments, the packet processing engine **548** may evaluate a variable that the packet processing engine **548** sets upon borrowing from the shared quota pool. The packet processing engine **548** may determine that borrowing occurred based upon the value of the variable.

If the packet processing engine **548** determines that the packet processing engine did not borrow from the shared quota pool, the packet processing engine **548** may complete a use of the resource. In some embodiments, the packet processing engine **548** may place the connection to the resource in a reuse pool. The reuse pool may be exclusive to the packet processing engine **548**. In these embodiments, when the packet processing engine **548** receives another request to use the resource, the packet processing engine **548** may access one of the connections to the resource in the reuse pool instead of opening a new connection to access the resource. In various embodiments, the packet processing engine **548** may close the connection to the resource.

If the packet processing engine determines **548** that the packet processing engine **548** borrowed from the shared quota pool, the packet processing engine **548** may determine if the number of completed uses of the resource is greater than or equal to the batch number. The packet processing engine **548** may make this determination by subtracting the exclusive number of uses from the current number of uses and comparing the result to the batch number. If the difference is less than the batch number, the packet processing engine **548** may complete a use of the resource and closes the connection to the resource. If the difference is equal to or greater than the batch number, the packet processing engine **548** may send a message to the pool manager **1165** indicating the return of a batch number of uses to the shared quota pool before completing the use and closing the connection. In these embodiments, the packet processing engine **548** may relinquish the lock acquired when the packet processing engine **548** borrowed from the shared quota pool. In various embodiments, upon receiving a message indicating that a batch number of uses is being returned to the shared quota pool, the pool manager **1165** may process requests for use of a resource in a queue of requests.

Although the methods of FIGS. **11** through **12**C may be generally discussed in reference to a packet engine and a spillover packet engine, the systems and methods of embodiments of the present solution may be used for virtual servers running on each core as part of the packet engine or separate from a packet engine to determine spillover thresholds and spillover persistence for virtual servers, such as any of the embodiments of spillover management and spillover persistence discussed in conjunction with FIGS. **7** to **10**B.

Referring to FIG. **12**D is another embodiment of steps of a method for managing spillover limits using the quota based allocation techniques described herein. In brief overview, at step **1291**, a spillover limit is identified for a multi-core device intermediary to a plurality of clients and one or more servers. The multi-code device may establish a virtual server **275** on each of the cores or packet processing engines to manage the services provided by the one or more servers. One or more of the virtual servers may have a backup virtual server for handling client requests when the virtual server reaches its spillover threshold. At step **1293**, based on the spillover limit, the pool manager of the device allocates a number of resources uses to each of the virtual managers. The number of resources may be allocated from an exclusive quota pool and/or a shared quota pool. At step **1295**, the device determines that one of the plurality of virtual servers has reached or exhausted its allocated number of resource uses. At step **1297**, responsive to the determination, the device forwards a received client request to a backup virtual server. At step **1299**, the device monitors the service, the spillover limits and allocation of resource uses.

In further details, at step **1291**, the multi-core device may be configured for any type of spillover limit, including but not limited to connection based spillover, dynamic connection based spillover, health based spillover and bandwidth bases spillover. The spillover limit or threshold may be configured as a maximum number of connections to a service of the one or more services. The spillover limit may be configured a dynamic connection threshold determined from a sum of a connection capacity of each of the plurality of virtual servers. The spillover limit may be configured as a bandwidth threshold.

Although the device has multiple cores and multiple virtual servers and/or packet engines operating on each core, a spillover limit may be configured or specified for the device itself. The spillover limit may identify or specify the type of resource—connection, health, bandwidth, etc. Using the pool management techniques herein, the multi-core device may allocate and manage the number of resource uses across the cores, packet engines and/or virtual servers. In some aspects, the multi-core device allocates and manages the numbers of resource uses for the spillover limit to appear as a single core device configured with a single spillover limit.

The multi-core device may be configured to operate or execute one or more virtual servers on each core of the device. Each of the virtual servers may manage one or more services executing on one or more servers. For each virtual server, one or more backup virtual servers may be configured, established or otherwise provided to handle client requests for the virtual server when the virtual server has reached its resource allocation corresponding to the spillover limit.

At step **1293**, using any embodiments of the resource management techniques described herein, the pool manager allocates a number of resource uses corresponding to the spillover limit across each of the cores or virtual servers operating on each core. The pool manager may establish an exclusive quota pool and/or shared quota pool for a total number of resources uses for the resource, such as connections, health or bandwidth of the spillover limit. In some embodiments, the pool manager allocates a number of exclusive resources to each core or virtual server from an exclusive quota pool. In some embodiments, the pool manager allocates a number of non-exclusive resource uses to each core or virtual server from a shared quota pool. In some embodiments, the pool manager allocates a number of resource uses to each core or virtual server from both an exclusive quota pool and a shared quota pool. In some embodiments, the pool manager may allocate an equal number of resources uses across each core or virtual server. In some embodiments, the pool manager may allocate an unequal number of resources uses across each core or virtual server. In some embodiments, the pool manager may allocate number of resources uses across each core or virtual server based on some weight assigned to the core or virtual server.

At step **1295**, the device determines that the number of resources used by a virtual server of the plurality of virtual servers has reached an allocated number of resource uses of the virtual server. In some embodiments, the virtual server determines that it has exhausted its allocated number of resource uses. In some embodiments, the virtual server requests additional resource uses from the pool manager. In some embodiments, the pool manager does not have resource uses to allocate to the virtual server. In some embodiments, the pool manager determines not to allocate any more resource uses to the virtual server. In some embodiments, the virtual server reaches its corresponding portion of the spillover limit when the virtual server has reached its allocated number of exclusive resource uses. In some embodiments, the virtual server reaches its corresponding portion of the spillover limit when the virtual server has reached its allocated number of non-exclusive resource uses. In some embodiments, the virtual server reaches its corresponding portion of the spillover limit when the virtual server has reached its allocated number of exclusive and non-exclusive resource uses. In some embodiments, the device reaches the spillover limit when each of the virtual servers has reaches its allocated number of exclusive and/or non-exclusive resources. In some embodiments, the device reaches the spillover limit when each of the virtual servers has reaches its corresponding portion of the spillover limit.

At step **1297**, the device forwards, responsive to the determination of step **1295**, to a backup virtual server a request of a client received by the device for the virtual server. In some embodiments, when any one virtual server of the plurality of virtual servers reaches its corresponding portion of the spillover limit or its corresponding allocation of resource users, the device redirects request to the virtual server to a corresponding backup virtual server. In some embodiments, when any all of the plurality of virtual servers reaches its corresponding portion of the spillover limit or its corresponding allocation of resource users, the device redirects requests to any of the virtual servers to a backup virtual server. In some embodiments, the connection manager determines when a spillover conditions exists and determines to forwards requests to a backup virtual server.

At step **1299**, the device monitors the services and may adjust the corresponding spillover limit. In some embodiments, one core or packet engine may be designated as the master core or packet engine for monitoring the service. In some embodiments, one core or packet engine may be designated as the master core or packet engine for monitoring the spillover limit. In some embodiments, one core or packet engine may be designated as the spillover master. The master core or packet engine may monitor one or more services bound to or managed by the plurality of virtual servers. For the case of spillover limits that change responsive to a state or status of the service, the master core or packet engine may adjust the spillover limit responsive to monitoring. For example, in some embodiments of dynamic connection spillover, the master core or packet engine may increase or decrease the dynamic connection spillover limit responsive to a change in the capacity of connections. In some embodiments of bandwidth spillover, the master core or packet engine may increase or decrease the bandwidth spillover limit responsive to a change in bandwidth capacity. In some embodiments of health spillover, the master core or packet engine may increase or decrease the health spillover limit responsive to a change in health status of a service(s).

The spillover master core or packet engine may propagate the change in spillover limits to each of the other cores or packet engines. In some embodiments, the spillover master may use any type and form of inter-core communications, such as core-to-core messaging or shared memory.

In some embodiments, each of the cores, packet engines or virtual servers may adapt or changes its allocation of a number of resource uses responsive to a change to the spillover limit. Responsive to a lower spillover limit or a decrease in the spillover limit, a virtual server or packet engine may return a number of resource uses to the pool manager. In some embodiments, a virtual server or packet engine may return a number of exclusive resource uses to the exclusive quota pool. In some embodiments, a virtual server or packet engine may return a number of non-exclusive resource uses to the shared quota pool. In some embodiments, a virtual server or packet engine may return both a number of exclusive uses to the exclusive quote pool and a number of non-exclusive resource uses to the shared quota pool. Responsive to a higher spillover limit or an increase in the spillover limit, a virtual server or packet engine may request an additional number of resource uses from the pool manager. In some embodiments, a virtual server or packet engine may request an additional number of exclusive resource uses to the exclusive quota pool. In some embodiments, a virtual server or packet engine may request an additional number of non-exclusive resource uses to the shared quota pool. In some embodiments, a virtual server or packet engine may request an additional number of exclusive uses for, the exclusive quote pool and an additional number of non-exclusive resource uses from the shared quota pool. In some embodiments, responsive to changes in the spillover limit, one packet engine or virtual server may return a number of resource uses (exclusive, non-exclusive or otherwise) while another packet engine or virtual server may request an additional number of resource uses (exclusive, non-exclusive or otherwise).

In some embodiments, the pool manager responsive to changes in the spillover limit, changes the allocations of resource uses across the plurality of cores, packet engines or virtual servers. In some embodiments, the pool manager may request a virtual server or packet engine to return a number of resource uses, exclusive, non-exclusive or otherwise. In some embodiments, the pool manager may increase for a virtual server or packet engine a number of resource uses, exclusive, non-exclusive or otherwise. In some embodiments, responsive to changes in the spillover limit or responsive to monitoring, the pool manager may request one virtual server or packet engine to return a number of resource uses, exclusive, non-exclusive or otherwise while providing an increasing the number of resource uses, exclusive, non-exclusive or otherwise, for another virtual server or packet engine.

In view of changes to the spillover limit, the device may perform spillover management to backup virtual servers based on the changed spillover limits and/or reallocation of number of resource uses across the virtual servers. In some embodiments, if requests for a virtual spillover were directed to a backup virtual server and the spillover limit increased or the virtual server's allocation of number of resource uses increases, request may be sent back to the virtual server instead of the backup virtual server. In some embodiments, if requests for a virtual spillover were not directed to a backup virtual server and the spillover limit decreased or the virtual server's allocation of number of resource uses decreases, spillover management may be triggers and request directed to the virtual server are redirected to the backup virtual server.

What is claimed:

1. A method of managing spillover via a plurality of cores of a multi-core device intermediary to a plurality of clients and one or more services, the method comprising:

a) identifying, for a device intermediary to a plurality of clients and one or more services, a spillover limit of a resource, the device comprising a plurality of virtual servers operating on a corresponding core of a plurality of cores of the device;

b) allocating, by a pool manager of the device, to each of the plurality of virtual servers, a number of uses of a resource from an exclusive quota pool and shared quota pool based on the spillover limit, the number of uses of the resources comprising a number of times the resource can be used;

c) determining, by the device, that the number of times the resource is used by a virtual server of the plurality of virtual servers has reached the allocated number of uses of the resource of the virtual server; and

d) forwarding, by the device responsive to the determination, to a backup virtual server a request of a client of the plurality of clients received by the device for the virtual server.

2. The method of claim **1**, wherein step (a) further comprises identifying for the device the spillover limit as a maximum number of connections to a service of the one or more services.

3. The method of claim **1**, wherein step (a) further comprises identifying for the device the spillover limit as a dynamic connection threshold, the dynamic connection threshold comprising a sum of a number of connections of each of the plurality of virtual servers.

4. The method of claim **1**, wherein step (b) further comprises allocating, by the pool manager, the number of uses of the resource comprising a number of exclusive uses from the exclusive quota pool and a number of non-exclusive uses from the shared quota pool.

5. The method of claim **1**, wherein step (c) further comprises requesting, by the virtual server, a resource use from the pool manager upon reaching the virtual server's allocation of uses of the resource.

6. The method of claim **1**, wherein step (c) further comprises determining, by the device, that the number of uses of the resource available from the pool manager for the virtual server has been exhausted.

7. The method of claim **1**, further comprising changing the spillover limit to a lower number of resource uses and responsive to the change, one or more of the plurality of virtual servers returning a portion of the allocated number of uses of the resource to the pool manager.

8. The method of claim **1**, further comprising changing the spillover limit to a higher number of uses of the resource and responsive to the change, one or more the plurality of virtual servers requesting from the pool manager an additional the number of uses of the resource.

9. The method of claim **1**, further comprising designating a first core of the plurality of cores as spillover master for monitoring the service and changing the spillover limit based on monitoring.

10. A system for managing spillover via a plurality of cores of a multi-core device intermediary to a plurality of clients and one or more services, the system comprising:

a device intermediary to a plurality of clients and one or more services, the device comprising:

a spillover limit of a resource;

a plurality of packet engines operating on a corresponding core of a plurality of cores of the device;

a pool manager allocating to each of the plurality of packet engines a number of uses of a resource from an exclusive quota pool and shared quota pool based on the spillover limit, the number of uses of the resources comprising a number of times the resource can be used; and

a virtual server of a packet engine of the plurality of packet engines, the virtual server managing client requests to one or more services;

wherein the device determines that the number of time the resource is used by a packet engine of the plurality of packet engine has reached the allocated number of uses of the resource of the packet engine, and responsive to the determination, forwards to a backup virtual server a request of a client of the plurality of clients received by the device for the virtual server.

11. The system of claim **10**, wherein the device identifies the spillover limit as a maximum number of connections to a service of the one or more services.

12. The system of claim **10**, wherein the device identifies the spillover limit as a dynamic connection threshold, the dynamic connection threshold comprising a sum of a number of connections of each of the plurality of virtual servers.

13. The system of claim **10**, wherein the pool manager allocates the number of uses of the resource comprising a number of exclusive uses from the exclusive quota pool and a number of non-exclusive uses from the shared quota pool.

14. The system of claim **10**, wherein the packet engine requests a resource use from the pool manager upon reaching the packet engine's allocation of the number of uses of the resource.

15. The system of claim **10**, wherein the device determines that the number of uses of the resource available from the pool manager has been exhausted.

16. The system of claim **10**, wherein the device changes the spillover limit to a lower number of uses of the resource and responsive to the change, one or more of the plurality of packet engines returning a portion of the allocated number of uses of the resource to the pool manager.

17. The system of claim **10**, wherein the device changes the spillover limit to a higher number of uses of the resource and responsive to the change, one or more the plurality of packet engines requesting from the pool manager an additional the number of resource uses.

18. The system of claim **10**, wherein the device designates a first packet engine of the plurality of packet engines as spillover master for monitoring the service and changing the spillover limit based on monitoring.

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